

SCHWESERNOTES™

FOR THE CFA® EXAM

CFA® | 2013

Level III | Book 4



Alternative Investments, Risk Management,
and Derivatives

KAPLAN SCHWESER



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BOOK 4 – ALTERNATIVE INVESTMENTS, RISK MANAGEMENT, AND DERIVATIVES

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SCHWESERNOTES™ 2013 CFA LEVEL III BOOK 4: ALTERNATIVE
INVESTMENTS, RISK MANAGEMENT, AND DERIVATIVES

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READINGS AND LEARNING OUTCOME STATEMENTS

READINGS

The following material is a review of the Alternative Investments, Risk Management, and Derivatives principles designed to address the learning outcome statements set forth by CFA Institute.

STUDY SESSION 13

Reading Assignments

Alternative Investments for Portfolio Management, CFA Program 2013 Curriculum, Volume 5, Level III

- | | |
|--|---------|
| 31. Alternative Investments Portfolio Management | page 8 |
| 32. Swaps | page 51 |
| 33. Commodity Forwards and Futures | page 59 |

STUDY SESSION 14

Reading Assignments

Risk Management, CFA Program 2013 Curriculum, Volume 5, Level III

- | | |
|------------------------------|----------|
| 34. Risk Management | page 75 |
| 35. Currency Risk Management | page 115 |

STUDY SESSION 15

Reading Assignments

Risk Management Applications of Derivatives, CFA Program 2013 Curriculum, Volume 5, Level III

- | | |
|--|----------|
| 36. Risk Management Applications of Forward and Futures Strategies | page 140 |
| 37. Risk Management Applications of Option Strategies | page 168 |
| 38. Risk Management Applications of Swap Strategies | page 218 |

LEARNING OUTCOME STATEMENTS (LOS)

The CFA Institute learning outcome statements are listed in the following. These are repeated in each topic review. However, the order may have been changed in order to get a better fit with the flow of the review.

STUDY SESSION 13

The topical coverage corresponds with the following CFA Institute assigned reading:

31. Alternative Investments Portfolio Management

The candidate should be able to:

- a. describe common features of alternative investments and their markets and how alternative investments may be grouped by the role they typically play in a portfolio. (page 8)
- b. explain and justify the major due diligence checkpoints involved in selecting active managers of alternative investments. (page 9)
- c. explain the special issues that alternative investments raise for investment advisers of private wealth clients. (page 10)
- d. distinguish among the principal classes of alternative investments, including real estate, private equity, commodity investments, hedge funds, managed futures, buyout funds, infrastructure funds, and distressed securities. (page 11)
- e. discuss the construction and interpretation of benchmarks and the problem of benchmark bias in alternative investment groups. (page 16)
- f. evaluate the return enhancement and/or risk diversification effects of adding an alternative investment to a reference portfolio (for example, a portfolio invested solely in common equity and bonds). (page 20)
- g. describe the advantages and disadvantages of direct equity investments in real estate. (page 24)
- h. discuss the major issuers and suppliers of venture capital, the stages through which private companies pass (seed stage through exit), the characteristic sources of financing at each stage, and the purpose of such financing. (page 25)
- i. compare venture capital funds and buyout funds. (page 26)
- j. discuss the use of convertible preferred stock in direct venture capital investment. (page 26)
- k. explain the typical structure of a private equity fund, including the compensation to the fund's sponsor (general partner) and typical timelines. (page 26)
- l. discuss the issues that must be addressed in formulating a private equity investment strategy. (page 27)
- m. compare indirect and direct commodity investment. (page 28)
- n. explain the three components of return for a commodity futures contract and the effect that an upward- or downward-sloping term structure of futures prices will have on roll yield. (page 28)
- o. describe the principle roles suggested for commodities in a portfolio and explain why some commodity classes may provide a better hedge against inflation than others. (page 29)
- p. identify and explain the style classification of a hedge fund, given a description of its investment strategy. (page 30)
- q. discuss the typical structure of a hedge fund, including the fee structure, and explain the rationale for high-water mark provisions. (page 32)

- r. describe the purpose and characteristics of fund-of-funds hedge funds. (page 33)
- s. critique the conventions and discuss the issues involved in hedge fund performance evaluation, including the use of hedge fund indices and the Sharpe ratio. (page 33)
- t. describe trading strategies of managed futures programs and the role of managed futures in a portfolio. (page 35)
- u. describe strategies and risks associated with investing in distressed securities. (page 37)
- v. explain event risk, market liquidity risk, market risk, and “J-factor risk” in relation to investing in distressed securities. (page 38)

The topical coverage corresponds with the following CFA Institute assigned reading:

32. Swaps

The candidate should be able to:

- a. evaluate commodity hedging strategies that rely on swaps and describe their inherent risk exposures. (page 51)

The topical coverage corresponds with the following CFA Institute assigned reading:

33. Commodity Forwards and Futures

The candidate should be able to:

- a. discuss pricing factors for commodity forwards and futures, including storability, storage costs, production and demand, and explain their influence on lease rates and the forward curve. (page 59)
- b. identify and explain how to exploit arbitrage situations that result from the convenience yield of a commodity and from commodity spreads across related commodities. (page 67)
- c. compare the basis risk of commodity futures with that of financial futures. (page 69)

STUDY SESSION 14

The topical coverage corresponds with the following CFA Institute assigned reading:

34. Risk Management

The candidate should be able to:

- a. discuss the main features of the risk management process, risk governance, risk reduction, and an enterprise risk management system. (page 75)
- b. evaluate the strengths and weaknesses of a company’s risk management process. (page 76)
- c. describe the characteristics of an effective risk management system. (page 76)
- d. evaluate a company’s or a portfolio’s exposures to financial and nonfinancial risk factors. (page 77)
- e. calculate and interpret value at risk (VAR) and explain its role in measuring overall and individual position market risk. (page 80)
- f. compare the analytical (variance–covariance), historical, and Monte Carlo methods for estimating VAR and discuss the advantages and disadvantages of each. (page 81)
- g. discuss the advantages and limitations of VAR and its extensions, including cash flow at risk, earnings at risk, and tail value at risk. (page 84)
- h. compare alternative types of stress testing and discuss the advantages and disadvantages of each. (page 86)

- i. evaluate the credit risk of an investment position, including forward contract, swap, and option positions. (page 88)
- j. demonstrate the use of risk budgeting, position limits, and other methods for managing market risk. (page 92)
- k. demonstrate the use of exposure limits, marking to market, collateral, netting arrangements, credit standards, and credit derivatives to manage credit risk. (page 94)
- l. discuss the Sharpe ratio, risk-adjusted return on capital, return over maximum drawdown, and the Sortino ratio as measures of risk-adjusted performance. (page 96)
- m. demonstrate the use of VAR and stress testing in setting capital requirements. (page 98)

The topical coverage corresponds with the following CFA Institute assigned reading:

35. Currency Risk Management

The candidate should be able to:

- a. explain and demonstrate the use of foreign exchange futures to hedge the currency exposure associated with the principal value of a foreign investment. (page 115)
- b. justify the use of a minimum-variance hedge when local currency returns and exchange rate movements are correlated and interpret the components of the minimum-variance hedge ratio in terms of translation risk and economic risk. (page 118)
- c. evaluate the effect of basis risk on the quality of a currency hedge. (page 120)
- d. discuss the choice of contract maturity in constructing a currency hedge, including the advantages and disadvantages of different maturities. (page 121)
- e. explain the issues that arise when hedging multiple currencies. (page 122)
- f. discuss the use of options rather than futures/forwards to manage currency risk. (page 123)
- g. evaluate the effectiveness of a standard dynamic delta hedge strategy when hedging a foreign currency position. (page 124)
- h. discuss and justify methods for managing currency exposure, including the indirect currency hedge created when futures or options are used as a substitute for the underlying investment. (page 127)
- i. discuss the major types of currency management strategies specified in investment policy statements. (page 127)

STUDY SESSION 15

The topical coverage corresponds with the following CFA Institute assigned reading:

36. Risk Management Applications of Forward and Futures Strategies

The candidate should be able to:

- a. demonstrate the use of equity futures contracts to achieve a target beta for a stock portfolio and calculate and interpret the number of futures contracts required. (page 141)
- b. construct a synthetic stock index fund using cash and stock index futures (equitizing cash). (page 144)
- c. explain the use of stock index futures to convert a long stock position into synthetic cash. (page 147)

- d. demonstrate the use of equity and bond futures to adjust the allocation of a portfolio between equity and debt. (page 148)
- e. demonstrate the use of futures to adjust the allocation of a portfolio across equity sectors and to gain exposure to an asset class in advance of actually committing funds to the asset class. (page 152)
- f. explain exchange rate risk and demonstrate the use of forward contracts to reduce the risk associated with a future receipt or payment in a foreign currency. (page 154)
- g. explain the limitations to hedging the exchange rate risk of a foreign market portfolio and discuss two feasible strategies for managing such risk. (page 157)

The topical coverage corresponds with the following CFA Institute assigned reading:

37. Risk Management Applications of Option Strategies

The candidate should be able to:

- a. compare the use of covered calls and protective puts to manage risk exposure to individual securities. (page 174)
- b. calculate and interpret the value at expiration, profit, maximum profit, maximum loss, breakeven underlying price at expiration, and general shape of the graph for the following option strategies: bull spread, bear spread, butterfly spread, collar, straddle, box spread. (page 178)
- c. calculate the effective annual rate for a given interest rate outcome when a borrower (lender) manages the risk of an anticipated loan using an interest rate call (put) option. (page 192)
- d. calculate the payoffs for a series of interest rate outcomes when a floating rate loan is combined with 1) an interest rate cap, 2) an interest rate floor, or 3) an interest rate collar. (page 197)
- e. explain why and how a dealer delta hedges an option position, why delta changes, and how the dealer adjusts to maintain the delta hedge. (page 205)
- f. interpret the gamma of a delta-hedged portfolio and explain how gamma changes as in-the-money and out-of-the-money options move toward expiration. (page 210)

The topical coverage corresponds with the following CFA Institute assigned reading:

38. Risk Management Applications of Swap Strategies

The candidate should be able to:

- a. demonstrate how an interest rate swap can be used to convert a floating-rate (fixed-rate) loan to a fixed-rate (floating-rate) loan. (page 218)
- b. calculate and interpret the duration of an interest rate swap. (page 224)
- c. explain the effect of an interest rate swap on an entity's cash flow risk. (page 225)
- d. determine the notional principal value needed on an interest rate swap to achieve a desired level of duration in a fixed-income portfolio. (page 226)
- e. explain how a company can generate savings by issuing a loan or bond in its own currency and using a currency swap to convert the obligation into another currency. (page 230)
- f. demonstrate how a firm can use a currency swap to convert a series of foreign cash receipts into domestic cash receipts. (page 231)
- g. explain how equity swaps can be used to diversify a concentrated equity portfolio, provide international diversification to a domestic portfolio, and alter portfolio allocations to stocks and bonds. (page 232)
- h. demonstrate the use of an interest rate swaption 1) to change the payment pattern of an anticipated future loan and 2) to terminate a swap. (page 235)

ALTERNATIVE INVESTMENTS PORTFOLIO MANAGEMENT¹

Study Session 13

EXAM FOCUS

This topic assignment provides an overview of major types of alternative investments and their roles in portfolio construction. Be prepared for questions relating to: 1) common elements and differences among alternative investments; 2) available benchmarks and measurement challenges; 3) strategies and role in the portfolio; and 4) due diligence issues. This is qualitative material so expect questions focusing on recall and understanding concepts.

ALTERNATIVE INVESTMENT FEATURES

LOS 31.a: Describe common features of alternative investments and their markets and how alternative investments may be grouped by the role they typically play in a portfolio.

CFA® Program Curriculum, Volume 5, page 7

Alternative investments offer diversification benefits and the potential for active management. There are six basic groups. Traditional alternative investments include *real estate*, *private equity*, and *commodities*. The more modern alternative investments include *hedge funds*, *managed futures*, and *distressed securities*.

Alternative investments can also be grouped by their role in portfolio management:

1. Real estate and long-only commodities offer exposure to risk factors and return that stocks and bonds cannot provide.
2. Hedge funds and managed futures offer exposure to special investment strategies and are heavily dependent on manager skill.
3. Private equity and distressed securities are seen as a combination of 1 and 2.

1. The terminology used throughout this topic review is industry convention as presented in Reading 31 of the 2013 CFA Level III exam curriculum. Empirical results are referenced in that reading as well.

Alternative investments can be highly unique and there are differences of opinion on how to group them. But they do share some common features:

1. *Low liquidity.* Their general lack of liquidity requires careful attention to determine if they are suitable for a given investor. The alternative investment should also be associated with a liquidity premium and higher return.
2. *Diversification.* They generally have low correlation with and offer significant diversification to traditional stock and bond portfolios.
3. *Due diligence costs.* Costs associated with researching and monitoring alternative investments can be high. Specialized expertise and specific business skills are often required. These markets frequently lack transparency, making information difficult to obtain.
4. *Difficult performance evaluation.* The lack of transparency and unique features of many strategies make it difficult to identify appropriate valuation benchmarks.

DUE DILIGENCE CHECKPOINTS

LOS 31.b: Explain and justify the major due diligence checkpoints involved in selecting active managers of alternative investments.

CFA® Program Curriculum, Volume 5, page 10

The lack of transparency and unique strategies of many alternative investment managers makes due diligence in manager selection crucial:

1. *Assess the market opportunity offered.* Are there exploitable inefficiencies in the market for the type of investments in which the manager specializes? Past returns do not justify selecting a manager unless there are understandable opportunities available for the manager to exploit. (This one would have stopped anyone from investing with Bernie Madoff.)
2. *Assess the investment process.* What is the manager's competitive edge over others in that market? How does the manager's process identify potential opportunities?
3. *Assess the organization.* Is it stable and well run? What has been the staff turnover?
4. *Assess the people.* Meet with them and assess their character, both integrity and competence.
5. *Assess the terms and structure of the investment.* What is the fee structure? How does it align the interest of the manager with the investors? What is the lock-out period? Many funds do not allow withdrawals for an initial period. What is the exit strategy for redeeming the funds invested?
6. *Assess the service providers.* Investigate the outside firms that support the manager's business (e.g., lawyers, brokers, ancillary staff).

7. *Review documents.* Review the prospectus or private-placement memorandum, the audits of the manager's reports, and other available documents. Seek legal and other expert advice where needed.
8. *Write-up.* Document the above review process.

ISSUES FOR PRIVATE WEALTH CLIENTS

LOS 31.c: Explain the special issues that alternative investments raise for investment advisers of private wealth clients.

CFA® Program Curriculum, Volume 5, page 11

Institutional investors are presumed to be more knowledgeable and dispassionate investors. Individuals can be less knowledgeable, more emotional, and have real issues that must be considered to determine suitability.

1. *Taxes.* Most individuals must pay taxes. Many alternative investments are structured as limited partnerships which require specialized tax expertise.
2. *Suitability.* Many alternative investments require that funds stay invested for a minimum time period. Is this compatible with the investor's time horizon and liquidity needs? What happens if the investor's situation changes? Individuals may have emotional feelings that draw them towards or repel them from some investments.
3. *Communication.* Discussing complex strategies with the client is not easy. When a client is excited about a unique opportunity, how do you make sure they really do understand a ten-year lock-out means they cannot get the money back for ten years? How do you explain the diversification benefit of a very complex strategy to someone with no investment training?
4. *Decision risk.* This could be defined as the risk of emotionally abandoning a strategy right at the point of maximum loss. Carefully communicating the expected ups and downs of a strategy and being prepared for the emotional response to the downside is hard. Some strategies offer frequent small returns but the occasional large loss. They maximize the chance of an emotional investor making the wrong decision to cash out after a loss. Other strategies offer wild swings between large gains and losses with an attractive long term average return.
5. *Concentrated positions.* Wealthy individuals' portfolios frequently contain large positions in closely held companies or private residences. Such ownership should be considered as a preexisting allocation before deciding to add additional private equity or real estate exposure. These existing positions may also have large unrealized taxable gains which add complexity to any rebalancing decision.

One approach to incorporating alternative investments into a traditional portfolio is *core-satellite*. The traditional core of the portfolio would remain as stocks and bonds to provide market exposure and return. However, it is difficult to add value in such efficient markets. More informationally inefficient alternative investments would be added to provide excess return (alpha) as the satellite.

ALTERNATIVE INVESTMENT CLASSES

LOS 31.d: Distinguish among the principal classes of alternative investments, including real estate, private equity, commodity investments, hedge funds, managed futures, buyout funds, infrastructure funds, and distressed securities.

CFA® Program Curriculum, Volume 5, page 13



Professor's Note: You might notice the CFA text just switched from six groups to eight classes. That is because infrastructure funds are a subgroup of real estate and buyout funds of private equity.

Real Estate

One way to classify real estate investment is between *direct* and *indirect*. *Direct* real estate investment includes ownership of residences, commercial real estate, or agricultural land. The ownership involves direct management of the assets. *Indirect* investment in real estate generally means there is a well-defined middle group that manages the properties. Indirect real estate investments include:

- Companies that develop and manage real estate.
- Real estate investment trusts (REITs), which are publicly traded equity shares in a portfolio of real estate. Equity REITs own and operate properties while mortgage REITs hold mortgages on real estate. REITs can be purchased in small sizes and are liquid.
- Commingled real estate funds (CREFs), which are pooled investments in real estate that are professionally managed and privately held, have more flexibility than REITs. They can be open-end and allow in new investors or closed-end and not allow in new investors after an initial offering period. They are restricted to wealthy investors and institutions.
- Separately managed accounts for wealthy investors are usually offered by the same managers who manage CREFs.
- **Infrastructure funds** specialize in purchasing public infrastructure assets (e.g., airports, toll roads) from cities, states, and municipalities. Because infrastructure assets typically provide a public service, they tend to produce relatively stable long-term returns. They tend to be regulated by local governments which adds to the predictability of cash flows. Their low correlation with equity markets means infrastructure assets provide diversification, and their long-term nature provides a good match for institutions with long-term liabilities (e.g., pension funds). Their relatively low risk, however, means that infrastructure returns are low.

The advantages of real estate investment typically include low correlation with stocks and bonds (providing a portfolio diversification benefit), low volatility of return, and often an inflation hedge. Real estate may also offer tax advantages and the potential to leverage return.

Disadvantages include high information and transaction costs, political risk related to the potential for tax law changes, high operating expenses, and the inability to subdivide direct investments. Real estate as an asset class and each individual real estate asset can have a large idiosyncratic risk component.

Private Equity

Private equity investment is an ownership interest in a non-publically-traded private company. Legal restrictions generally limit ownership to high-net-worth individuals or institutions. Often, the investing is done through pooling funds with other investors in a **private equity fund**. There are numerous subcategories of private equity. The two most important are **venture capital**, which provides funding to start or grow a private company, and **buyout funds**, which provide funds to buy existing public companies from their shareholders and then take the company private.

Two important segments of buyout funds are *middle-market buyout funds* and *mega-cap buyout funds*. Middle-market buyout funds concentrate on divisions spun off from larger, publicly traded corporations and private companies that, due to their relatively small size, cannot efficiently obtain capital. Mega-cap buyout funds concentrate on taking publicly traded firms private.

Buyout funds add value through some combination of: 1) restructuring company operations and management, 2) buying companies for less than intrinsic value, and 3) creating value by adding leverage or restructuring existing debt of the company. The exit strategies include selling the companies through private placements or IPOs or through *dividend recapitalizations*. In a dividend recapitalization, the company (under direction of the buyout fund) issues substantial debt and pays a large special dividend to the buyout fund and other equity investors. The debt effectively replaces some or most of the equity of the company, while allowing the investors to recoup some or all of their original investment. *Recapitalization* increases the company's leverage but does not change the owner. The buyout fund retains control but extracts cash from the company.

Private equity is a highly diverse class that typically involves high risk with a significant number of investments that fail. The venture capitalist is often expected to bring not only funding but business expertise to operate the company. The entrepreneurs who start the company often lack the capital and management skills to grow the company. The company may employ agents to solicit private equity investors through a private placement memorandum which describes the business plan, risk, and many other details of the investment.

Commodities

Commodity investments can include *direct* purchase of the physical commodity (e.g., agricultural products, crude oil, metals) or the purchase of derivatives (e.g., futures) on those assets. *Indirect* investment in commodities can include investment in companies whose principal business is associated with a commodity (e.g., investing in a metal via ownership of shares in a mining company). Direct investment through derivatives is more common as indirect investment has not tracked well with commodity price changes and direct investment by buying the commodities creates issues to consider such as storage costs.

Investments in both commodity futures and publicly traded commodity companies are fairly liquid, especially when compared to many other alternative investments. Investments in commodities have common risk features such as *low correlation with*

stocks and bonds and business-cycle sensitivity, and most have a *positive correlation with inflation*. These risk characteristics are the reasons commodities provide good diversification to an investor's portfolio.

Hedge Funds

Hedge funds are a diverse group and the terminology used to describe them is flexible. Initially they were private pools of money that were both long and short the market. Hence, they were not exposed to market risk. Many hedge funds still target an absolute level of return that is not dependent on market returns. Hedge funds are generally structured to avoid regulation which also allows them to charge substantial incentive fees. Each fund is designed to exploit a perceived market opportunity, often taking both long and short positions on a leveraged basis. Many hedge funds describe themselves as exploiting arbitrage opportunities. In the case of hedge funds the term "arbitrage" is used very loosely to mean lower-risk and not to mean risk-free.

Hedge fund classifications include: *equity market neutral*, *convertible arbitrage*, *fixed-income arbitrage*, *distressed securities*, *merger arbitrage*, *hedged equity*, *global macro*, *emerging markets*, and *fund of funds (FOF)*.



Professor's Note: For a discussion of these terms see LOS 31.p.

Managed Futures

Managed futures funds are sometimes classified as hedge funds. Others classify them as a separate alternative investment class. In the United States, they generally use the same limited partnership legal structure and base fee plus performance fee compensation structure as hedge funds. A 2% base fee plus a 20% share of the profits is a common fee structure. Like hedge funds, they are often considered to be skill based and not an asset class, per se; they depend on the skill of the manager to find and exploit opportunities and as such have no inherent return and risk characteristics of their own.

The primary feature that distinguishes managed futures from hedge funds is the difference in the assets they hold. For example, managed futures funds tend to trade only in derivatives markets, while hedge funds often trade in spot and futures markets. Also, managed futures funds generally take positions based on indices, while hedge funds tend to focus more on individual asset price anomalies. In other words, hedge funds tend to have more of a micro focus, while managed futures tend to have a macro focus. In some jurisdictions they are more regulated than hedge funds.

Investment in managed futures can be done through: *private commodity pools*, *managed futures programs as separately managed accounts* (called CTA managed accounts), and *publicly traded commodity futures funds* that are available to small investors. *Liquidity* will be lower for private funds than for publicly traded commodity futures funds.

Trading strategies and classifications used include:

- *Systematic trading strategies* follow rules. *Trend following rules* are common and may focus on short-, medium-, or long-term trends. *Contrarian strategies* exist but are less common.
- *Discretionary trading strategies* depend on the judgment of the manager and could be based on economic or other criteria.
- Managed futures may invest in all *financial* markets, *currency* markets only, or a *diversified* mix of derivatives and underlying commodities.

The *risk characteristics* of managed futures will vary, as they do for hedge funds. A trend-following strategy will offer lower diversification than a contrarian strategy. The standard deviation of managed futures is generally less than that of equities but greater than that of bonds. The correlation between managed futures and equities is low and often negative. With bonds, the correlation is higher but still less than 0.50.

Distressed Securities

Distressed securities are securities of companies that are in or near bankruptcy. They are another type of alternative investment where the risk and return depend upon skill-based strategies. Some analysts consider distressed securities to be part of the hedge fund class or of the private equity class.

One way to construct subgroups in distressed securities is by structure, which determines the level of liquidity. The hedge fund structure for distressed security investment is more liquid. The private equity fund structure describes funds that are less liquid because they have a fixed term and are closed-ended. The latter structure is more appropriate when the underlying securities are too illiquid to overcome the problem of determining a net asset value (NAV).

Figure 1 presents a summary of alternative investment characteristics.

Figure 1: Alternative Investment Characteristics

	<i>Types of Investments</i>	<i>Risk/Return Features</i>	<i>Liquidity</i>
Real estate	Residences; commercial real estate; raw land.	Large idiosyncratic risk component; provides good diversification.	Low.
Private equity	Preferred shares of stock; venture capital; buyout funds.	Start-up and middle-market private companies have more risk and lower returns than investments in established companies via buyout funds.	Low.
Buyout funds	Well-established private firms and corporate spin-offs.	Less risk than venture capital funds; good diversification.	Low.
Infrastructure funds	Public infrastructure assets.	Low risk, low return; good diversification.	Low.
Commodities	Agricultural products; crude oil; metals.	Low correlation with stocks/bonds. Positive correlation with inflation.	Fairly liquid.
Managed futures	Tend to trade only in derivatives market. Private commodity pools; publicly traded commodity futures funds.	Risk is between that of equities and bonds. Negative and low correlations with equities and low-to-moderate correlations with bonds.	Lower for private funds than for publicly traded commodity futures funds.
Distressed securities	May be part of hedge fund class or private equity class. Investments can be in debt and/or equity.	Depends on skill-based strategies. Can earn higher returns due to legal complications and the fact that some investors cannot invest in them.	Hedge fund structure more liquid; private equity structure less liquid.

For the Exam: The various types of alternative investment classes appear in several places throughout the curriculum. Hedge funds in particular are discussed several times and real estate receives more coverage than some of the other topics. Commodities are examined in greater detail later in this study session. You will be able to find small inconsistencies in the discussions so focus on the main points of agreement and be aware of areas that may be more controversial. The published topic weight for alternative investments is 5–15%.

ALTERNATIVE INVESTMENT BENCHMARKS

LOS 31.e: Discuss the construction and interpretation of benchmarks and the problem of benchmark bias in alternative investment groups.

CFA® Program Curriculum, Volume 5, page 15

For the Exam: Be ready to discuss the general properties, including the drawbacks, of alternative investment benchmarks.

Appropriate benchmarks for a given alternative investment manager can be difficult to establish. The following list describes the more common benchmarks available and some of the issues that arise.

- **Real estate** has the National Council of Real Estate Investment Fiduciaries (NCREIF) Property Index as its principal benchmark for *direct investments*. The NCREIF Index is a *value-weighted* index of commercially owned properties that uses samples based both on geographic location and type (e.g., apartment and industrial). The values are obtained periodically, usually by annual appraisal, so the volatility of the index is *downward biased*. The index is published quarterly.

For *indirect* real estate investment, the primary benchmark is the National Association of Real Estate Investment Trusts (NAREIT) Index. The NAREIT Index is cap-weighted and includes all REITs traded on the NYSE or AMEX. Similar to other indices based upon current trades, the monthly NAREIT Index is “live” (i.e., its value represents current values).

The biggest problem is the infrequent trading of most real estate investments and the resulting understatement of actual volatility. Various techniques have been used to *unsmooth* or “correct” this bias. The unsmoothed data raises the standard deviation and reduces the Sharpe ratio of real estate, making real estate less attractive but still a valuable addition to stock and bond portfolios due to its low correlation. Another problem is that many real estate indices reflect leveraged investments. When leverage effects are removed, returns and Sharpe ratios are lower, but the low correlation with other asset classes still leaves real estate as an attractive addition to portfolios. Finally, in the case of REITS, the returns are more correlated with equity while other types of real estate investment are less correlated with equity, meaning REITS offer less of a diversification benefit.

- **Private equity** indices are provided by Cambridge Associates and Thomson Venture Economics. Indices are constructed for the buyout and venture capital (VC) segments of the private equity markets. Because private equity values are not readily available, the value of a private equity index depends upon events like IPOs, mergers, new financing, and so on to provide this information. Thus, the indices might present dated values as *repricing* occurs infrequently. Note that private equity investors also often construct custom benchmarks.

The primary problems are the lack of pricing data, forcing a heavy reliance on appraisal values for investments, and the resulting smoothing of returns and understatement of volatility. In addition, private equity shows a strong vintage year

effect. The economic conditions of the year in which the fund was launched have a significant effect on subsequent performance for the life of the fund. As a result, comparisons are often made to other funds launched in the same year.

- **Commodity markets** have many indices for use as benchmarks. Most of them assume a futures-based strategy. For example, the Dow Jones-UBS Commodity Index (DJ-UBSCI) and the S&P Commodity Index (S&PCI) represent returns associated with passive long positions in futures.

The indices include exposures to most types of commodities and are considered *investable*. They can vary widely, however, with respect to their purpose, composition, and method of weighting the classes. Given the zero-sum nature of futures, the indices cannot use a market-cap method of weighting. Two methods of weighting are 1) basing weights on world production of the underlying commodities and 2) basing weights on the perceived relative worldwide importance of the commodity. The various indices use either arithmetic or geometric averaging to calculate component returns.



Professor's Note: Although there are other characteristics an index must meet to be considered investable, the easiest way to look at it is whether an investor can actually hold the index by purchasing all the assets in the index in the same weights as in the index. For example, an investor can purchase and hold all the stocks of the S&P 500. If that cannot be done, the index is not investable.

- **Managed futures** have several investable benchmarks. Some common benchmarks, such as the Mount Lucas Management Index (MLMI), replicate the return to a *mechanical, trend-following strategy*. The strategies usually include utilizing both long and short positions using trading rules based upon changes in technical indicators. Other benchmarks, such as the CTA Indices published by the Center for International Securities and Derivatives Markets (CISDM), are indices based upon *peer-group managed futures funds*. They can use *dollar-weighted* (CTA\$) or *equal-weighted* (CTAEQ) returns from databases of separately managed accounts. Among these indices there are benchmarks based upon the level of discretionary management and the underlying market, as well as trend-following or contrarian.
- **Distressed securities** funds are often considered a hedge fund subgroup. Most of the index providers for hedge funds have a sub-index for distressed securities. Benchmarks in this area have the same characteristics as long-only hedge fund benchmarks.

Figure 2 presents a summary of these alternative investment benchmarks, their construction, and their associated biases. Hedge fund benchmarks are then discussed separately.

Figure 2: Alternative Investment Benchmarks

	<i>Benchmarks</i>	<i>Construction</i>	<i>Biases</i>
Real estate	NCREIF; NAREIT.	NCREIF is value weighted; NAREIT is cap weighted.	Measured volatility is downward biased. The values are obtained periodically (annually).
Private equity	Provided by Cambridge Associates and Thomson Venture Economics.	Constructed for buyout and venture capital. Value depends upon events. Often construct custom benchmarks.	Repricing occurs infrequently which results in dated values.
Commodities	Dow Jones-UBS Commodity Index; S&P Commodity Index.	Assume a futures-based strategy. Most types considered investable.	Indices vary widely with respect to purpose, composition, and method of weighting.
Managed futures	MLMI; CTA Indices.	MLMI replicates the return to a trend-following strategy. CTA Indices use dollar-weighted or equal-weighted returns.	Requires special weighting scheme.
Distressed securities	Characteristics similar to long-only hedge fund benchmarks.	Weighting either equally weighted or based upon assets under management. Selection criteria can vary.	Self-reporting; backfill or inclusion bias; popularity bias; survivorship bias.

Hedge Fund Benchmarks

Hedge fund benchmarks vary a great deal in composition and even frequency of reporting. Also, there is no consensus as to what defines hedge fund strategies and this leads to many differences in the indices, as style classifications vary from company to company. The following points summarize the ways index providers compose their respective indices.

- *Selection criteria* can vary, and methods include assets under management, the length of the track record, and the restrictions imposed on new investment.
- *Style classification* also varies as to how they classify a fund by style and whether it is included in a given index.
- *Weighting schemes* are usually either equally weighted or based upon assets under management.
- *Rebalancing rules* must be defined for equally weighted indices, and the frequency can vary from monthly to annually.
- *Investability* often depends upon frequency of reporting (e.g., daily reporting allows for investability while monthly reporting tends not to). Some indices are not explicitly investable, but independent firms modify the index to produce an investable proxy.

Some indices explicitly report the funds they include in the composition of the index, and some do not. Some indices report monthly and some report daily. Examples of providers of *daily indices* are Hedge Fund Research (HFR), Dow Jones (DJ), and

Standard & Poor's (S&P). The DJ and S&P explicitly list the funds included in their indices and use an equal-weighting approach.

The following lists providers of *monthly indices* with a few of their general characteristics:

- *CISDM of the University of Massachusetts*: several indices that cover both hedge funds and managed futures (equally weighted).
- *Credit Suisse/Tremont*: provides various benchmarks for different strategies and uses a weighting scheme based upon assets under management.
- *EACM Advisers*: provides the EACM100[®] Index, an equally weighted index of 100 funds that span many categories.
- *Hedge Fund Intelligence, Ltd.*: provides an equally weighted index of over 50 funds.
- *HedgeFund.net*: provides an equally weighted index that covers more than 30 strategies.

Hedge fund benchmark selection includes several issues:

- **Relevance of past data** may be questionable. If hedge funds are a reflection of manager skill, then past returns for indices is less relevant to future returns since hedge fund indices frequently change composition and thus managers within the index. The empirical evidence shows that funds within a particular style do have similar returns and that individual managers do not consistently beat their style group. The data also suggests volatility of past returns tends to persist even when return does not. This makes selection of the relevant comparison benchmark very important.
- **Popularity bias** can result if one of the funds in a value-weighted index increases in value and then attracts a great deal of capital. The inflow of investment to that fund will have a misleading effect on the index. Research has shown that indices can easily suffer from a popularity bias of a particular style, which is caused by inflows and not the actual return on investment. Even without the popularity bias, a dramatic increase in one style can bias an index. The problem with equally weighted indices is that they are not rebalanced often and effectively. This lowers their investability.
- **Survivorship bias** is a big problem for hedge fund indices. Indices may drop funds with poor track records or that fail, causing an upward bias in reported values. Studies have shown that the bias can be as high as 1.5–3% per year. The degree of survivorship bias varies among the hedge fund strategies. It is lower for event-driven strategies and higher for hedged equity strategies.
- **Stale price bias** varies depending on the markets used by the hedge fund. If the fund operates in markets with infrequent trading, the usual issues of appraisal or infrequent pricing and the resulting understatement of volatility can arise. The evidence suggests this is not a large problem.
- **Backfill or inclusion bias** is a similar problem but arises from filling in missing past data. It tends to be directionally biased, as only managers who benefit from the missing data have an incentive to supply the data. It seems to be an issue with some indices.

RETURN ENHANCEMENT AND DIVERSIFICATION

LOS 31.f: Evaluate the return enhancement and/or risk diversification effects of adding an alternative investment to a reference portfolio (for example, a portfolio invested solely in common equity and bonds).

CFA® Program Curriculum, Volume 5, page 18

Real Estate

Real estate is an asset class as well as an alternative investment. High risk-adjusted performance is possible because of the low liquidity, large lot sizes, immobility, high transactions costs, and low information transparency that usually means the seller knows more than the buyer.

Real estate typically reacts to macroeconomic changes differently than stocks and bonds, and each investment has a large idiosyncratic (unsystematic) risk component. Because of both of these characteristics, real estate has provided diversification. Using data for the period 1990–2004, Figure 3 compares the returns of the indicated portfolios based on benchmarks for the indicated asset classes.

Figure 3: Portfolio Returns From 1990–2004

<i>Measure (annualized)</i>	<i>50/50 Stock/Bonds</i>	<i>40/40/20 Stocks/Bonds/REITs</i>	<i>40/40/20 Stocks/Bonds/ Unsmoothed NCREIF</i>
Return	9.60%	10.34%	9.33%
Standard deviation	7.87%	7.62%	6.59%
Sharpe ratio	0.67	0.79	0.77

Some conclusions from Figure 3 and past data include:

- Adding either direct real estate or REITs to a stock/bond portfolio significantly increases the portfolio Sharpe ratio.
- The Sharpe ratio using REITs is only slightly better than the Sharpe ratio using direct real estate even though REITs had a higher return for the period because direct real estate produces a better diversification effect.

Private Equity

Private equity is less of a diversifier and more a long-term return enhancer. Private equity investments (both venture capital and buyout funds) are usually illiquid, require a long-term commitment, and have a high level of risk with the potential for complete loss. In addition, there is often a minority discount associated with the investment. Because of these issues, investors require a high expected internal rate of return (IRR). Venture capital investments have lower transparency than buyout funds, which can actually add to the potential for large profits.

The difference in transparency between venture capital funds and buyout funds is caused by the different natures of the investments. Venture capital, for example, is provided to new, non-public companies in need of capital for growth. By definition, the managers of firms receiving the funds have considerably more information on the true value of the firm than the investing public. This adds to the risk faced by venture capital funds but, at the same time, increases the possible return to venture capitalists, who make it a point to learn as much about the firm as possible before investing. Buyout funds, on the other hand, usually provide capital to managements and others to purchase the equity of publicly traded firms.

Private equity returns typically move with stock market returns. Computed correlations are often positive and low, but some attribute the low correlation to the infrequently updated (i.e., “stale”) prices of the private equity. Each investment has a large idiosyncratic risk component, however, which can provide moderate diversification.

Because the primary benefit from private equity is return enhancement, Figure 4 gives the most important information for comparison. From the figure, we see that in the most recent years, venture capital funds and buyout funds had a lower return than both small-cap and large-cap stocks (NASDAQ and S&P). Over the long term of 20 years, however, private equity had higher returns.

Figure 4: Returns to Private Equity and Equity Markets

<i>Period</i>	<i>NASDAQ</i>	<i>S&P 500</i>	<i>VC Funds</i>	<i>Buyout Funds</i>
2002–2005	22.4%	14.7%	4.9%	14.7%
2000–2005	–10.1%	–3.1%	–9.3%	3.1%
1995–2005	7.5%	7.7%	26.5%	8.7%
1985–2005	12.3%	11.2%	16.5%	13.3%

Commodities

Commodities chiefly offer *diversification* to a portfolio of stocks and bonds. Correlations of commodity indices with stocks and bonds have been low and even slightly negative. With the exception of the *agricultural subgroups*, commodity indices have a strong positive correlation with inflation. That is a benefit to the investor because they provide a hedge against inflation, while stocks and bonds are hurt by inflation.

The returns on commodities have generally been lower than stocks and bonds over the period 1990–2004, both on an absolute basis and a risk-adjusted basis. The *energy subgroup* of commodities has had the highest returns, and without it, the broad GSCI index return would have been much lower. Figure 5 gives the statistics for 1990–2004.

Figure 5: Index Returns From 1990–2004

<i>Measure (annualized)</i>	<i>S&P 500</i>	<i>Lehman Government/ Corporate Bond Index</i>	<i>GSCI¹ (broad commodity index)</i>
Return	10.94%	7.77%	7.08%
Standard deviation	14.65%	4.46%	19.26%
Sharpe ratio	0.45	0.78	0.15

1. Goldman Sachs Commodity Index

Commodities have had higher returns in more recent years. For the sub-period of 2000–2004, the GSCI average return of 13.77% was higher than both the –2.30% return for stocks and the 8.0% return on bonds. The high volatility of commodities, however, still gave it a lower Sharpe ratio than bonds (0.5 for commodities as compared to 1.11 for bonds).

We see how commodities play a useful role in the portfolio in Figure 6, which compares a 50/50 stock/bond portfolio to a portfolio with an allocation to commodities. The return is slightly lower, but the Sharpe ratio is higher.

Figure 6: Portfolio Returns From 1990–2004

<i>Measure (annualized)</i>	<i>50/50 Stock/Bonds</i>	<i>40/40/20 Stocks/Bonds/GSCI</i>
Return	9.60%	9.51%
Standard deviation	7.87%	7.19%
Sharpe ratio	0.67	0.73

Because commodities had a higher return in more recent years and stocks had a negative average return, commodities enhanced portfolio returns even more for the most recent years, as shown in Figure 7.

Figure 7: Portfolio Returns From 2000–2004

<i>Measure (annualized)</i>	<i>50/50 Stock/Bonds</i>	<i>40/40/20 Stocks/Bonds/GSCI</i>
Return	3.15%	5.66%
Standard deviation	7.93%	7.60%
Sharpe ratio	0.06	0.39

Hedge Funds

Hedge funds generated higher absolute and risk-adjusted returns than stocks and bonds over the period 1990–2004. The Hedge Fund Composite Index (HFCI) return, standard

deviation, and Sharpe ratio were 13.46%, 5.71%, and 1.61, respectively. Hedge funds ranked between bonds and stocks in the more recent period of 2000–2004, where the corresponding numbers were 6.84%, 4.83%, and 0.86. For the more recent period, the mean return and Sharpe ratio is higher than the measures for stocks, but they are both lower than the measures for bonds.

As was the case for most of the previous alternative investments, a 40/40/20 stock/bond/HFCI portfolio had a higher return and lower standard deviation than the 50/50 stock/bond portfolio over both the 1990–2004 and 2000–2004 periods.

Hedge funds vary widely, however, so the benefits of investing in one of any given style will differ. Figure 8 provides a representative list of the best and worst performing funds with their correlations with the S&P 500 and the Lehman Government/Corporate Bond Index. The last two rows in Figure 8 comment on each index's return and how well it added diversification over the period 1990–2004.

Figure 8: Hedge Fund Strategy Index Performance From 1990–2004

<i>Measure (annualized)</i>	<i>Short Selling</i>	<i>MSCI World</i>	<i>Fixed-Income Arbitrage</i>	<i>Equity Hedge</i>	<i>Global Macro</i>	<i>HFCI (composite)</i>
Return	−0.61%	7.08%	7.62%	15.90%	16.98%	13.46%
Standard deviation	19.39%	14.62%	3.61%	9.34%	8.38%	5.71%
Sharpe ratio	−0.25	0.19	0.92	1.24	1.51	1.61
Correlation w/ S&P 500	−0.76	0.86	0.06	0.64	0.26	0.59
Correlation w/ bonds	−0.01	0.09	−0.06	0.10	0.34	0.17
Performance	Poor	Moderate	Moderate	Good	Good	Good
Diversification	Good	Poor	Good	Moderate	Good	Moderate

Managed Futures

Managed futures are usually considered a category of hedge funds and are usually compared to stocks and bonds, but their record has been similar to that of hedge funds. Over the period 1990–2004, the dollar-weighted index of separately managed accounts (CTA\$) had a return, standard deviation, and Sharpe ratio equal to 10.85%, 9.96%, and 0.66, respectively, which is about the same as stocks but with a better Sharpe ratio. They also had a higher return than bonds with a lower Sharpe ratio.

The CTA\$ also ranked between bonds and stocks from 2000–2004. The corresponding numbers were 7.89%, 8.66%, and 0.60. The return was certainly higher than the −2.30% return for stocks and slightly less than the 8.0% return for bonds; however, the Sharpe ratio for bonds was higher at 1.11.

A portfolio consisting of 36/36/18/10 of stocks/bonds/HFCI/CTA\$ accounts had a higher return and Sharpe ratio than a 40/40/20 stocks/bonds/HFCI portfolio for both the longer 1990–2004 and shorter 2000–2004 periods.

Note that actively managed separate accounts are those where the managers seek to take advantage of mispricing opportunities. There is evidence that short-term momentum and other strategies can produce excess returns. Managed futures seem to provide unique returns and diversification benefits. This is made evident from the near-zero correlation (-0.01) between the index of separately managed accounts and a 50/50 stock/bond fund.

Distressed Securities

Distressed security returns have had a relatively high average return but a large negative skew, so the comparisons using averages and Sharpe ratios can be misleading. They can provide high returns because many investors cannot hold distressed-debt securities, and few analysts cover the market. Based on comparisons of the average return and Sharpe ratio, the HFR Distressed Securities Index outperformed both stocks and bonds, both on an absolute and on a risk-adjusted basis. The returns are often event-driven, so they are uncorrelated with the overall stock market.

For the Exam: The diversification benefits of alternative investments are also discussed in Study Session 8, Asset Allocation. Be prepared to determine whether alternative investments are appropriate for a client's portfolio considering the client's objectives and constraints. For the exam, this is particularly relevant for a morning case where you need to allocate among several asset classes. Remember from Study Session 8 that there are drawbacks to adding alternative investments to a portfolio (e.g., amount of capital required, lack of liquidity) but there are also benefits (e.g., diversification, return enhancement).

REAL ESTATE EQUITY INVESTING

LOS 31.g: Describe the advantages and disadvantages of direct equity investments in real estate.

CFA® Program Curriculum, Volume 5, page 19

Direct equity real estate investing has the following advantages and disadvantages.

Advantages:

- Many expenses are tax deductible.
- Ability to use more leverage than most other investments.
- Direct control of the properties.
- Ability to diversify geographically.
- Lower volatility of returns than stocks even after correcting for smoothing.

Disadvantages:

- Lack of divisibility means a single investment may be a large part of the investor's portfolio.
- High information costs.
- High commissions.
- High operating and maintenance costs plus hands-on management requirements.
- Special geographical risks, such as neighborhood deterioration.
- Political risks, such as changing tax codes.

VENTURE CAPITAL INVESTING

LOS 31.h: Discuss the major issuers and suppliers of venture capital, the stages through which private companies pass (seed stage through exit), the characteristic sources of financing at each stage, and the purpose of such financing.

CFA® Program Curriculum, Volume 5, page 26

In a typical sequence, the venture capitalist brings capital to start a company based on an attractive business plan and/or to fund and grow an existing private company. The typical exit plan involves an IPO (initial public offering) to sell stock to the public and pay off the early private investors. This can take years to execute.

There is an extensive vocabulary to describe venture capital. The issuers (companies seeking capital) of venture capital include *formative-stage companies* that are either new or young and *expansion-stage companies* that need funds to expand their revenues or prepare for an IPO.

The investors (suppliers) include:

- **Venture capitalists** are specialists who identify pools of capital available for investing in and find the promising private companies to invest in. They may pool investor's capital into **venture capital funds or trusts**.
- **Corporate venturing** refers to large companies that invest in venture capital opportunities in their own area of business expertise.
- **Angel investors** are considered to be knowledgeable, accredited individuals who are often the first outsiders (non-founders or relatives) who invest in the company.

The **stages** through which private companies pass are early stage, expansion stage, and exit stage. The *early stage* includes *seed money* often put up by the entrepreneur or other family members to begin prototype work, then *start-up funds* to begin product development and marketing, and *first-stage funding* to begin manufacturing and sales.

The *expansion stage* can include very young companies with an established product looking to expand sales, more established companies seeking to fund growth, or even companies soon to launch an IPO. *Second-stage* financing supports further expansion of production and sales, while *third-stage* financing can support additional major expansion. *Mezzanine or bridge financing* is used to prepare for an IPO and may include both debt and equity capital.

The *exit stage* could involve an IPO, merger with another company, or acquisition by another company (which might be a venture capital fund specializing in such activity).

LOS 31.i: Compare venture capital funds and buyout funds.

CFA® Program Curriculum, Volume 5, page 38

In contrast to venture capital funds, **buyout funds** usually have:

- A higher level of leverage.
- Earlier and steadier cash flows.
- Less error in the measurement of returns as more of the return is from cash flow return.
- Less frequent losses.
- Less upside potential.

These differences are the natural consequence of buyout funds purchasing entities in later stages of development or established companies and corporate spin-offs, where the risks are lower.

CONVERTIBLE PREFERRED STOCK

LOS 31.j: Discuss the use of convertible preferred stock in direct venture capital investment.

CFA® Program Curriculum, Volume 5, page 32

Convertible preferred stock is a good vehicle for direct venture capital investment because preferred stockholders must be paid a specified amount (e.g., twice their initial investment) before common stockholders can receive cash in the form of dividends or other distributions. Any buyout of the company that is favorable to shareholders will lead to the conversion of the preferred stock. Typically, investors in subsequent rounds of financing receive preferred stock with a claim that is senior to any previously issued preferred stock. Seniority is included to entice subsequent investors and makes those preferred shares more valuable than those issued earlier.

PRIVATE EQUITY INVESTING

LOS 31.k: Explain the typical structure of a private equity fund, including the compensation to the fund's sponsor (general partner) and typical timelines.

CFA® Program Curriculum, Volume 5, page 32

Private equity funds usually take the form of **limited partnerships** or **limited liability companies** (LLCs). These legal structures limit the loss to investors to the initial investment and avoid corporate double taxation. For limited partnerships, the sponsor is called the *general partner*; for LLCs, the sponsor is called the *managing director*. The sponsor constructs and manages the fund and selects and advises the investments.

The **time line** starts with the sponsor getting commitments from investors at the beginning of the fund and then giving “capital calls” over the first five years (typically). This is referred to as the *commitment period*. The expected life of these funds is seven to ten years, and there is often an option to extend the life up to five more years.

The sponsor can receive *compensation* in several ways. First, the sponsor has capital invested that earns a return. This is usually required, as it helps keep the sponsor’s interests in line with those of the limited partners. As a manager, the sponsor typically gets a *management fee* and *incentive fee*.

The **management fee** is usually 1.5% to 2.5% and is based upon the *committed funds*, not just funds already invested. The percent may decline over time based upon the assumption that the manager’s work declines over time.

The **incentive fee** is also called the *carried interest*. It is the share of the profits, usually around 20%, that is paid to the manager after the fund has returned the outside investors’ capital—often after a minimum required return or hurdle rate has been paid on the cash from the outside investors. In some cases, the manager can receive early distributions based on expectations, but a *claw-back* provision may be in place that requires the manager to give back money if the expected profits are not realized.

PRIVATE EQUITY INVESTMENT STRATEGY

LOS 31.1: Discuss the issues that must be addressed in formulating a private equity investment strategy.

CFA® Program Curriculum, Volume 5, page 40

Any strategy for private equity investment must address the following issues:

- *Low liquidity*: the portfolio allocation to this class should typically be 5% or less with a plan to keep the money invested for seven to ten years.
- *Diversification through a number of positions*: because commitments are usually large, only investors with portfolios over \$100 million can invest in the necessary five to ten investments needed for diversification. Diversified, commingled funds exist for smaller investors, but these funds have additional fees.
- *Diversification strategy*: knowing the unique aspects of a proposed private equity investment as they relate to the overall portfolio.
- *Plans for meeting capital calls*: committed funds are called as needed, and the investor needs to be prepared to meet the calls.

COMMODITY INVESTING

LOS 31.m: Compare indirect and direct commodity investment.

CFA® Program Curriculum, Volume 5, page 43

Direct commodity investment entails either purchasing the actual commodities or gaining exposure via derivatives. Indirect commodity investment is the purchase of indirect claims (e.g., shares in a corporation) that deal in the commodity.

Direct investment gives more exposure, but cash investment in commodities can incur carrying costs. Indirect investment may be more convenient, but it may provide very little exposure to the commodity, especially if the company is hedging the risk itself.

The increase in the number of investable indices in commodities and their associated futures is indicative of the advantages of investing via derivatives. These indices also make investing in commodities available to smaller investors.

THE TERM STRUCTURE OF FUTURES PRICES

LOS 31.n: Explain the three components of return for a commodity futures contract and the effect that an upward- or downward-sloping term structure of futures prices will have on roll yield.

CFA® Program Curriculum, Volume 5, page 48

The components of the return to a commodity futures contract are the *spot return*, the *collateral return*, and the *roll return*. These components are usually considered to be additive, so one component can be calculated given the value of the others:

$$\text{total return} = \text{spot return} + \text{collateral return} + \text{roll return}$$

Spot return or **price return** of the underlying commodity. For example, if corn prices rise 2% for the period, the spot return for the futures contract is 2%. Spot return can be positive or negative.

Collateral return is the periodic risk-free return. The implicit assumption is that cash equivalents equal to the full price of the contract position are held. For example, if corn contracts are held one month and the periodic risk-free rate is 0.3%, the collateral return is 0.3%. Collateral return will be positive.

Roll yield or **return** is the change in the futures contract price for the time period minus the change in the spot price of the commodity for the period. It can be positive or negative and is affected by the shape of the futures term structure. **Backwardation** is a downward-sloping term structure of futures prices (i.e., each successive futures price is lower). Such a condition predicts a positive roll return, as the futures price increases to converge with the spot price at the expiration of the contract. If the term structure is upward-sloping, called **contango**, the roll return would be negative.

Example: Calculating the roll return to a commodity futures contract

The change in price on a futures contract is \$6, the spot return is \$3, and the collateral return is \$1. Calculate the roll return.

Answer:

$$\text{roll return} = \text{change in futures price} - \text{spot return} = \$6 - \$3 = \$3$$

The collateral return is not part of the change in the futures price and is not included in the calculation for the roll return.

COMMODITIES AND INFLATION

LOS 31.o: Describe the principle roles suggested for commodities in a portfolio and explain why some commodity classes may provide a better hedge against inflation than others.

CFA® Program Curriculum, Volume 5, page 52

Commodities generally provide a diversification benefit to traditional portfolios. Some commodities also provide specific diversification and protection against unexpected increases in inflation. Two factors affect whether a commodity is a good hedge against unexpected inflation: *storability* and demand relative to *economic activity*.

Whether a commodity is *storable* is the primary determinant in its value providing a hedge against unexpected inflation. For example, the values of storable commodities such as precious metals (e.g., gold, silver), industrial metals (e.g., zinc, aluminum, copper), and energy (e.g., crude oil, heating oil, natural gas) are positively related to unexpected changes in inflation. That is, they tend to increase (decrease) in value with unexpected increases (decreases) in inflation. They have provided good diversification against unexpected inflation.

Non-storable commodities like agricultural commodities (e.g., livestock, wheat, corn) have shown values that are negatively (positively) affected by unexpected increases (decreases) in inflation. They have not provided diversification against unexpected inflation.

Another factor to consider with respect to inflation hedging capability is whether the commodity's demand is linked to economic activity. Those that enjoy a more or less constant demand regardless of the level of economic activity, for example, seem to provide little hedge against unexpected changes in inflation. Again, agricultural commodities tend to fall into this group. Those commodities that are most affected by the level of economic activity (e.g., energy, precious metals) tend to be better hedges.

HEDGE FUND CLASSIFICATIONS

LOS 31.p: Identify and explain the style classification of a hedge fund, given a description of its investment strategy.

CFA® Program Curriculum, Volume 5, page 57



Professor's Note: The following material relates to LOS 31.d and 31.p.

Hedge funds are classified in various ways by different sources. Because hedge funds are a “style-based” asset class, strategies can determine the subgroups. Within the strategies, there can be even more precise subgroups such as long/short and long-only strategies. The following is a list of nine of the more familiar hedge fund strategies.

1. *Convertible arbitrage* seeks to exploit mispricings or anomalies in the price of convertible securities such as convertible bonds, convertible preferred stock, or warrants. Both long and short positions are taken to hedge the risks. A common example is to buy undervalued convertible bonds and short the stock. The investor owns the convertible which includes a “call option” on the stock and shorts the stock which should leave the position hedged against changes in the stock price. Interest is earned from the bond coupons and from investing the proceeds of the short-sale. The strategy would benefit if stock volatility increases and the convertible rises in value. (The value of the embedded call option in the convertible should rise with increasing volatility.) If the yield curve is upward sloping, making the yield on the bond higher than short term borrowing rates, the strategy might also be leveraged to enhance returns.
2. *Distressed securities* are fundamentally different investments than conventional debt and equity investments. Many investors are not allowed to or do not want to deal with the legal complications for these securities. The resulting securities may be undervalued and offer superior returns. Distressed securities are generally illiquid, making it difficult or impossible to short the securities. These funds are generally long (not hedged) portfolios.
3. *Emerging markets* generally only permit long positions, and often there are no derivatives to hedge the investments.
4. *Equity market neutral* typically combines long and short positions in under-valued and over-valued securities (pairs trading) to eliminate systematic risk while capitalizing on mispricing.
5. *Hedged equity strategies* take long and short positions in under- and over-valued securities to exploit mispricings. Unlike market neutral funds, they do not seek to remove systematic risk. They might be net long, short, or hedged based on the manager's view of the markets.

6. *Fixed-income arbitrage* involves taking long and short positions in fixed-income instruments based upon expected changes in the yield curve and/or credit spreads.
7. *Global macro strategies* take positions in major financial and non-financial markets through various means (e.g., derivatives and currencies). The distinguishing feature is that they tend to focus on an entire group or area of investment instead of individual securities or classes of securities.
8. *Merger arbitrage* or *deal arbitrage* focuses on returns from mergers, spin-offs, takeovers, and so on. For example, if Company X announces it will acquire Company Y, the manager might buy shares in Y and short X.
9. *Fund of funds (FOF)* describes a hedge fund that invests in many hedge funds. The idea is to get diversification among hedge fund managers or styles, but there is a fee paid to the manager of the fund of funds, as well as to the managers of the funds in the fund of funds.

Another classification scheme divides hedge funds strategies into five general segments: 1) *relative value*, 2) *event-driven*, 3) *hedged equity*, 4) *global asset allocators*, and 5) *short selling*.

1. *Relative value* strategies attempt to exploit price discrepancies. This category combines the equity market neutral, the convertible arbitrage, and fixed-income arbitrage strategies mentioned previously. As the name implies, this strategy compares the relative values of assets and attempts to capitalize, through various long and short strategies, on the relative mispricing.
2. *Event-driven* strategies invest with a short-term focus on an event like a merger (merger arbitrage) or the turnaround of a distressed company (distressed securities).
3. *Equity hedge* entails taking long and short equity positions with varying overall net long or short positions and can include leverage.
4. *Global asset allocators* take long and short positions in a variety of both financial and non-financial assets.
5. *Short selling* takes short-only positions in the expectation of a decline in value.

As a skill-based investment class, the risk and return of a hedge fund depends heavily upon the skill of the manager. We can make a distinction concerning risk, however, in that styles that are mainly long-only (e.g., distressed securities) tend to offer less potential for diversification than long/short styles, and liquidity can vary from fund to fund or even within subgroups.

HEDGE FUND STRUCTURE

LOS 31.q: Discuss the typical structure of a hedge fund, including the fee structure, and explain the rationale for high-water mark provisions.

CFA® Program Curriculum, Volume 5, page 59

The most common compensation structure of a hedge fund consists of an *assets-under-management (AUM)* fee of about 1% to 2% and an *incentive fee* of 20% of profits. The definition of *profit* should be spelled out in the terms of the investment. It could be the dollar return over the initial investment, for example, or the dollar return above the initial investment increased by some hurdle rate.

High water marks (HWMs) are typically employed to avoid incentive fee double-dipping. For example, assume a fund is valued and opened for subscription on a quarterly basis. Each quarter, the increase in value over the previous quarter is determined and investors pay incentive and management fees accordingly. This is fine, as long as the fund's value is higher at each successive valuation. If the value of the fund is lower than the previous quarter, however, the manager receives only the management fee, and the previous high value of the fund (i.e., the last fund value at which incentive fees were paid) is established as a HWM. Investors are then required to pay incentive fees only if and when the value of the fund rises above the HWM. Note that HWMs are investor- and subscription-date specific. For those who subscribe while the fund value is below the previously established HWM, that HWM is not relevant. They will pay management fees each quarter, as well as incentive fees, for increases in value above the value at their subscription date.

A **lock-up period** is a common provision in hedge funds. Lock-up periods limit withdrawals by requiring a minimum investment period (e.g., one to three years) and designating exit windows. The rationale is to prevent sudden withdrawals that could force the manager to have to unwind positions.

Incentive fees are paid to encourage the manager to earn ever-higher profits. There is some controversy concerning incentive fees because the manager should have goals other than simply earning a gross return. For example, the manager may be providing limited downside risk and diversification. An incentive fee based upon returns does not reward this service.

Managers with good track records often demand higher incentive fees. The concern for investors is whether the manager with a good historical record can continue to perform well enough to truly earn the higher fees.

FUND OF FUNDS

LOS 31.r: Describe the purpose and characteristics of fund-of-funds hedge funds.

CFA® Program Curriculum, Volume 5, page 58

A fund of funds (FOF) is a hedge fund that consists of several, usually 10 to 30, hedge funds. The point is to achieve diversification, but the extra layer of management means an extra layer of fees. Often, an FOF offers more liquidity for the investor, but the cost is cash drag caused by the manager keeping extra cash to meet potential withdrawals by other investors. Despite the drawbacks, FOF are *good entry-level investments*.

An FOF may be a better indicator of aggregate hedge fund performance than the typical hedge fund index because it suffers from less survivorship and backfill bias. If an FOF includes a hedge fund that dissolves, it includes the effect of that failure in its return, while an index may simply drop the failed fund along with its historical performance.

An FOF can, however, suffer from style drift. This can produce problems because the investor may not know what she is getting. Over time, individual hedge fund managers may tilt their respective portfolios in different directions. Also, it is not uncommon for two FOF that claim to be of the same style to have returns with a very low correlation.

FOF returns have been more highly correlated with equity markets than those of individual hedge funds. This characteristic has important implications for their use as diversifiers in an equity portfolio.

HEDGE FUND PERFORMANCE EVALUATION

LOS 31.s: Critique the conventions and discuss the issues involved in hedge fund performance evaluation, including the use of hedge fund indices and the Sharpe ratio.

CFA® Program Curriculum, Volume 5, page 63

The hedge fund industry views hedge fund performance appraisal as a major concern with many special issues and conventions to address. One special issue is that some claim that hedge funds are **absolute-return vehicles**, which means that no direct benchmark exists. Instead, the fund targets some absolute return per period. That target return is not really a benchmark because it is not investable. The question (and problem) is how to determine alpha. The problem is especially perplexing given that most performance evaluation techniques are based on long-only positions and hedge funds use various combinations of long and short positions and leverage. To create comparable portfolios, analysts might 1) use a single- or multi-factor model or 2) create tracking portfolios that have comparable return and risk characteristics. In either case, the resulting customized benchmark is used for subsequent evaluation.

Conventions to consider in hedge fund performance evaluation are the impact of performance fees and lock-up periods, the age of funds, and the size of funds. Empirical studies have found that:

- Funds with longer lock-up periods tend to produce higher returns than those with shorter lock-up periods.
- Younger funds tend to outperform older funds.
- Large funds underperform small funds.

Returns. By convention, hedge funds report monthly returns by comparing the ending value of the fund to the beginning value [i.e., $(V_1 / V_0) - 1$]. These simply-calculated monthly returns are then compounded to arrive at annual returns. Note that returns are often biased by entry into and exit from the fund, which are allowed on a quarterly or less frequent basis, and by the frequency of the manager's trading (i.e., cash flows).



Professor's Note: You will see in the GIPS® material in Study Session 18 that the way cash flows are handled affects the resulting return calculations.

To smooth out variability in hedge fund returns, investors often compute a *rolling return*, such as a 12-month moving average. A 12-month moving average is the average monthly return over the most recent 12 months, including the current month. The next moving average return is calculated by adding the next month and dropping the most distant month. In this fashion, the average return is always calculated using returns for 12 months.

Leverage. The convention for dealing with leverage is to treat an asset as if it were fully paid for (i.e., effectively “look through” the leverage). When derivatives are included, the same principle of *deleveraging* is applied.

Risk. Using standard deviation to measure the risk of a hedge fund can produce misleading results. For example, hedge fund returns are usually skewed with significant leptokurtosis (fat tails), so standard deviation fails to measure the true risk of the distribution (i.e., standard deviation does not accurately measure the probability of returns in the tails).

Downside deviation. Downside deviation measures only the dispersion of returns below some specified threshold return. The most common formula for downside deviation is:

$$\text{downside deviation} = \sqrt{\frac{\sum_{t=1}^n [\min(\text{return}_t - \text{threshold}, 0)^2]}{n-1}}$$

The threshold return in the formula is usually either zero or the risk-free rate of return. If the threshold is a recent average return, then we call the downside deviation the *semivariance*. The point of these measures is to focus on the negative returns and not penalize a fund for high positive returns, which increases measured standard deviation.



Professor's Note: It is fairly easy to visualize how earning a few very high returns in conjunction with average returns could produce a large standard deviation, even when the manager produced no negative returns. In this case, we should properly conclude that the manager performed well on a risk-adjusted basis, but using standard deviation to measure variability (i.e., risk) could lead us to conclude that the manager took unnecessary risk.

The Sharpe Ratio

Annual hedge fund Sharpe ratios are calculated using annualized measures, as discussed earlier:

$$\text{Sharpe}_{\text{HF}} = \frac{\text{annualized return} - \text{annualized risk-free rate}}{\text{annualized standard deviation}}$$

In addition to concerns associated with the way returns are calculated, the Sharpe ratio has the following *limitations* with respect to hedge fund evaluation:

- *Time dependency:* The annual Sharpe ratio is typically estimated using shorter time periods. For example, to estimate the annual Sharpe ratio for a hedge fund using quarterly returns, the analyst multiplies the quarterly return by 4 and multiplies the quarterly standard deviation by the square root of 4. Thus, the *annualized* Sharpe ratio is biased upward by the square root of 4.
- *Assumes normality:* Measures that incorporate standard deviation are inappropriate for skewed return distributions.
- *Assumes liquidity:* Because of infrequent, missing, or assumed return observations, illiquid holdings have upward-biased Sharpe ratios (i.e., downward-biased standard deviations).
- *Assumes uncorrelated returns:* Returns correlated across time will artificially lower the standard deviation. For example, if returns are trending for a period of time, the measured standard deviation will be lower than what may occur in the future. Serially-correlated returns also result when the asset is illiquid and current prices are not available (e.g., private equity investments).
- *Stand-alone measure:* Does not automatically consider diversification effects.

In addition to these statistical shortcomings, the Sharpe ratio has been shown to have little power for predicting winners (i.e., it uses historical data). Also, research has found evidence that managers can manipulate their reported returns to artificially inflate their Sharpe ratio.

MANAGED FUTURES

LOS 31.t: Describe trading strategies of managed futures programs and the role of managed futures in a portfolio.

CFA® Program Curriculum, Volume 5, page 88

Managed futures programs are typically run by **Commodity Pool Operators (CPOs)**. CPOs can themselves be **commodity trading advisors (CTAs)** or will hire CTAs to

actually manage all or part of the pool. In the United States, both must be registered with the U.S. Commodity Futures Trading Commission and the National Futures Association.

Managed futures (CTAs) are typically classified by style, the markets in which they specialize, or by strategy. Because they often seek performance in major markets, managed futures are sometimes thought of as a subset of global macro hedge funds that specialize in trading derivatives.



Professor's Note: Some CTAs prefer not to work within the structure of a private or public pool (CPO).

CTA strategies can be described as systematic or discretionary. CTAs that specialize in systematic trading strategies typically apply sets of rules to trade according to short-, intermediate-, and/or long-term trends. They may also trade counter to trends in a contrarian (against the trend) strategy.

A **discretionary** trading strategy is much as it sounds. The strategy is based on the discretion of the CTA (commodity trading advisor), in the same way that any active manager seeks value.

Managed futures can also be classified according to the markets in which they trade. They apply systematic or discretionary trading strategies in financial markets, currency markets, or diversified markets.

In *financial markets*, they trade in financial (i.e., interest rate) and currency futures, options, and forward contracts. Those that specialize in *currency markets* trade exclusively in currency derivatives. A fund that trades in *diversified markets* trades in all the financial derivatives markets described as well as commodity derivatives.

Role in the Portfolio

The primary benefit to managed futures is the significant diversification potential (i.e., improved Sharpe ratios). For example, some research has even shown that managed futures have exhibited positive correlation to equities and bonds during up markets and negative correlations during falling markets, although the performance seems to be related to specific strategies and time periods. In particular, private funds seem to add value whereas publicly traded funds have performed poorly, both stand-alone and in portfolios.

In selecting a CTA to include in the portfolio, the manager should consider risk. For example, even though CTAs often exhibit negative correlations with equities, correlations among CTAs themselves can range anywhere from significantly positive (i.e., close to 1.0) to only modestly positive. In addition, the beta that relates the performance of an individual CTA to a fund of CTAs can be a good indicator of future risk-adjusted performance. Just as equity beta relates the volatility (risk) of an individual equity security or portfolio to the overall equity market, the CTA beta measures the risk of the individual CTA relative to a fund of CTAs.

DISTRESSED SECURITIES INVESTING

LOS 31.u: Describe strategies and risks associated with investing in distressed securities.

CFA® Program Curriculum, Volume 5, page 93

The major types of distressed securities investing strategies are long-only value investing, distressed debt arbitrage, and private equity.

Long-only value investing basically tries to find opportunities where the prospects will improve and, of course, tries to find them before other investors do. *High-yield investing* is buying publicly traded, below-investment grade debt. *Orphan equities investing* is the purchase of the equities of firms emerging from reorganization. The reason these present a market opportunity is that some investors cannot participate in this market and many do not wish to do the necessary due diligence.



Professor's Note: An issue of debt that has fallen from investment grade to below-investment grade is referred to as a "fallen angel."

Distressed debt arbitrage is the purchasing of a company's distressed debt while short selling the company's equity. The investment can earn a return in two ways: 1) if the firm's condition declines, the debt and equity will both fall in value; the equity should decline more in value, though, because debt has seniority; and 2) if the company's prospects improve, because of the priority of interest over dividends, the returns to bondholders should be greater than that of equity holders, including dividends paid on the short position. The possibility of returns from the two events provides a good market opportunity.

Private equity is an "active" approach where the investor acquires positions in the distressed company, and the investment gives some measure of control. The investor can then influence and assist the company as well as acquire more ownership in the process of any reorganization. By providing services and obtaining a strategic position, the investors create their own opportunities. *Vulture funds*, which specialize in purchasing undervalued distressed securities, engage in this type of strategy.

CONCERNS OF DISTRESSED SECURITIES INVESTING

LOS 31.v: Explain event risk, market liquidity risk, market risk, and “J-factor risk” in relation to investing in distressed securities.

CFA® Program Curriculum, Volume 5, page 99

Distressed securities can have event risk, market liquidity risk, market risk, J-factor risk, and other types of risk.

- **Event risk** refers to the fact that the return on a particular investment within this class typically depends on an event for the particular company. Because these events are usually unrelated to the economy, they can provide diversification benefits.
- **Market liquidity risk** refers to low liquidity and the fact that there can be cyclical supply and demand for these investments.
- **Market risk** from macroeconomic changes is usually less important than the first two types mentioned.
- **J-factor risk** refers to the role that courts and judges can play in the return, and this involves an unpredictable human element. By anticipating the bankruptcy court judge's rulings (the J-factor), the distressed security investor knows whether to purchase the distressed company's debt or equity.

KEY CONCEPTS

LOS 31.a

Common features of alternative investments include:

- Low liquidity.
- Good diversification potential.
- High due diligence costs.
- Difficult to value.
- Limited access to information.

Alternative investments can provide:

- Exposure to asset classes that stocks and bonds cannot provide.
- Exposure to special investment strategies (e.g., hedge and venture capital funds).
- Special strategies and unique asset classes (e.g., funds that invest in private equity and distressed securities).

LOS 31.b

- Assess the market opportunity offered. Are there exploitable inefficiencies in the market for the type of investments in which the manager specializes?
- Assess the investment process. Does the manager seem to have a competitive edge over others in that market?
- Assess the organization of the manager and its operations. Is it stable and well run? What has been the staff turnover?
- Assess the people by meeting with them and assessing their character.
- Assess the terms and structure (amount and time period) of the investment.
- Assess the service providers (i.e., lawyers, brokers, ancillary staff, etc.) by investigating the outside firms that support the manager's business.
- Review documents such as the prospectus or private-placement memorandum and the audits.

LOS 31.c

- Taxes. Tax issues can be unique to the individual because the characteristics of private-wealth clients and their investments can vary greatly. For individuals, there can be partnerships, trusts, and other situations that make tax issues complex.
- Suitability. Time horizons and wealth of individuals can vary a great deal. With individuals, there is also the emotional aspect, like preferences for, or aversion to, certain types of assets.
- Communication. Communication with the client helps determine suitability of recommendations and the overall management process.
- Decision risk. Decision risk is the risk of irrationally changing a strategy. For example, the adviser must be prepared to deal with a client who wants to get out of a position that has just declined in value.
- Concentrated positions. Wealthy individuals' portfolios frequently contain large positions in closely held companies. Such ownership should be considered with the overall allocation to alternative investments, like private equity.

LOS 31.d

Real estate can be broken down into direct and indirect investment. Examples of direct investment in real estate include ownership of residences, commercial real estate, or agricultural land, and it involves direct management of the assets. Indirect real estate investments include:

- Companies that develop and manage real estate.
- Real estate investment trusts (REITs).
- Commingled real estate funds (CREFs).
- Separately managed accounts.
- Infrastructure funds.

Private equity subgroups include start-up companies, middle-market private companies, and private investment in public entities. A direct investment in private equity is when the investor purchases a claim directly from the firm (e.g., preferred shares of stock). Indirect investment is usually done through private equity funds, which include venture capital (VC) and buyout funds.

Commodity investments can also be grouped into direct and indirect subgroups. Direct investment is either through the purchase of the physical commodity or the purchase of derivatives (e.g., futures) on those assets. Indirect investment in commodities is usually done through investment in companies whose principal business is associated with a commodity (e.g., investing in a metal via ownership of shares in a mining company). Many commodities have a low correlation with stocks and bonds and a positive correlation with inflation.

Managed futures funds share many characteristics with hedge funds. The primary feature that distinguishes managed futures from hedge funds is the difference in the assets they hold. Managed futures funds tend to trade only in derivatives markets, while hedge funds tend to trade in spot markets and use futures for hedging. Also, managed futures funds generally take positions based on indices, while hedge funds tend to focus more on individual asset price anomalies. In other words, hedge funds tend to have more of a micro focus, while managed futures tend to have a macro focus.

Buyout funds are the largest segment of the private equity market. Middle-market buyout funds concentrate on divisions spun off from larger, publicly traded corporations and private companies that, due to their relatively small size, cannot efficiently obtain capital. Mega-cap buyout funds concentrate on taking publicly traded firms private. In either case, the target represents an investment opportunity through the identification of under-valued assets, the ability to restructure the debt of the firm, and/or improved (i.e., more efficient) management and operations.

Infrastructure funds specialize in purchasing public infrastructure assets (e.g., airports, toll roads) from cities, states, and municipalities. Distressed securities are securities of companies that are in or near bankruptcy. As with managed futures, analysts often consider distressed securities to be part of the hedge fund class of alternative investments. It may also be part of the private equity class.

LOS 31.e

Real Estate: *Benchmarks:* NCREIF, NAREIT. *Construction:* NCREIF is value weighted, NAREIT is cap weighted. *Biases:* Measured volatility is downward biased. The values are obtained periodically (annually).

Private Equity: *Benchmarks:* Provided by Cambridge Associates and Thomson Venture Economics. *Construction:* Constructed for buyout and venture capital. Value depends upon events. Often construct custom benchmarks. *Biases:* Repricing occurs infrequently, which results in dated values.

Commodities: *Benchmarks:* Dow Jones-UBS Commodity Index, S&P Commodity Index. *Construction:* Assume a futures-based strategy. Most types considered investable. *Biases:* Indices vary widely with respect to purpose, composition, and method of weighting.

Managed Futures: *Benchmarks:* MLMI, CTA Indices. *Construction:* MLMI replicates the return to a trend-following strategy. CTA Indices use dollar-weighted or equal-weighted returns. *Biases:* Requires special weighting scheme.

Distressed Securities: *Benchmarks:* Characteristics similar to long-only hedge fund benchmarks. *Construction:* Weighting either equally weighted or based upon assets under management. Selection criteria can vary. *Biases:* Self-reporting, backfill or inclusion bias, popularity bias, and survivorship bias.

LOS 31.f

Over the long term, in most cases, a 20% investment in alternative investments would have improved both the absolute return and the risk-adjusted return of a stock/bond portfolio. Over the 1990–2004 time period, adding managed futures to a portfolio of stocks, bonds, and hedge funds increased the return and the Sharpe ratio. Private equity provided less diversification than the other classes but provided return enhancement. Distressed securities have been found to provide both diversification and return enhancement.

LOS 31.g

Advantages of direct equity real estate investing:

- Many expenses are tax deductible.
- Ability to use more leverage than most other investments.
- Provides more control than stock investing.
- Ability to diversify geographically.
- Lower volatility of returns than stocks.

Disadvantages of direct equity real estate investing:

- Lack of divisibility means a single investment may be a large part of the investor's portfolio.
- High information cost, high commissions, high operating and maintenance costs, and hands-on management requirements.
- Special geographical risks, such as neighborhood deterioration and the political risk of changing tax codes.

LOS 31.h

Venture capital issuers include formative-stage companies and expansion-stage companies.

Venture capital buyers include angel investors, venture capitalists, and large companies (i.e., strategic partners).

A private company typically goes through the following stages.

- The early stage consists of three phases:
 - ♦ Seed.
 - ♦ Startup.
 - ♦ First stage.
- The later stage occurs after revenue has started and funds are needed to expand sales.
- The exit stage is the time when the venture capitalist realizes the value of the investment. It can occur through a merger, an acquisition, or an IPO.

LOS 31.i

In contrast to venture capital funds, buyout funds usually have:

- A higher level of leverage.
- Earlier and steadier cash flows.
- Less error in the measurement of returns.
- Less frequent losses.
- Less upside potential.

These differences are the natural consequence of buyout funds purchasing entities in later stages of development or even established companies where the risks are lower.

LOS 31.j

Convertible preferred stock is a good vehicle for direct venture capital investment. This is because preferred stockholders must be paid a specified amount (e.g., twice their initial investment) before common stockholders can receive cash in the form of dividends or other distributions. Any buyout of the company that is favorable to shareholders will lead to the conversion of the preferred stock. Typically, investors in subsequent rounds of financing receive preferred stock with a claim that is senior to any previously issued preferred stock. Seniority is included to entice subsequent investors and make those preferred shares more valuable than those issued earlier.

LOS 31.k

Private equity funds usually take the form of limited partnerships or limited liability companies (LLCs). These legal structures limit the loss to investors to the initial investment and avoid corporate double taxation. For limited partnerships, the sponsor is called the general partner; for LLCs, the sponsor is called the managing director.

The time line starts with the sponsor getting commitments from investors at the beginning of the fund and then giving “capital calls” over the first five years (typically), which are referred to as the commitment period. The expected life of these funds is seven to ten years, and there is often an option to extend the life up to five more years.

The sponsor can receive compensation in several ways. First, the sponsor has capital invested that earns a return. This is usually required as it helps keep the sponsor’s interests in line with those of the limited partners. As a manager, the sponsor typically gets a management fee of around 2% and an incentive fee of about 20% of the profits.

LOS 31.l

Any strategy for private equity investment must address the following issues:

- Low liquidity: Portfolio allocation to this class should be 5% or less with a plan to keep the money invested for 7 to 10 years.
- Diversification through a number of positions: Only investors with portfolios over \$100 million can invest in the 5 to 10 investments needed for diversification. Diversified commingled funds exist, but these funds have additional fees.
- Diversification strategy: Know how the proposed private equity investment relates to the overall portfolio.
- Plans for meeting capital calls: Committed funds are only called as needed, and the investor needs to be prepared to meet the calls.

LOS 31.m

Direct commodity investment entails either purchasing the actual commodities or gaining exposure via derivatives. Indirect commodity investment is the purchase of indirect claims (e.g., shares in a corporation) that deal in the commodity.

Direct investment gives more exposure, but cash investment in commodities can incur carrying costs. Indirect investment may be more convenient, but it may provide very little exposure to the commodity, especially if the company is hedging the risk itself.

The increase in the number of investable indices in commodities and their associated futures is indicative of the advantages of investing via derivatives. These indices also make investing in commodities available to smaller investors.

LOS 31.n

The components of the return to a commodity futures contract are the spot return, collateral return, and the roll return:

$$\text{total return} = \text{spot return} + \text{collateral return} + \text{roll return}$$

As the name implies, the spot return (i.e., price return) is the return on the futures caused by the change in the underlying commodity's spot price. The collateral return (i.e., collateral yield) is assumed to be the risk-free rate.

If an investor is long a contract and invests the value of the futures in T-bills, he will be able to pay for the required purchase at the futures' maturity. Such a fully-hedged (i.e., fully-collateralized) position should earn the risk-free rate.

Backwardation produces a downward-sloping term structure of futures prices (i.e., each successive futures price is lower). Such a condition predicts a positive roll return, as the futures prices increase to the spot prices. If the term structure is positive, which is a result of contango, the roll return is negative.

LOS 31.o

It appears that whether a commodity is *storable* is the primary determinant in its value providing a hedge against unexpected inflation. For example, the values of storable commodities such as precious metals, industrial metals, and energy are positively related to unexpected changes in inflation. That is, they tend to increase (decrease) in value with unexpected increases (decreases) in inflation.

Nonstorable commodities, on the other hand, tend to exhibit the opposite behavior. Agricultural commodities (e.g., livestock, wheat, corn) tend to fall into this category. Their values are negatively (positively) affected by unexpected increases (decreases) in inflation.

Another factor to consider with respect to inflation hedging capability is whether the commodity's demand is linked to economic activity. Those that enjoy a more or less constant demand regardless of the level of economic activity, for example, seem to provide little hedge against unexpected changes in inflation.

LOS 31.p

Hedge funds are classified in various ways by different sources. Because hedge funds are a “style-based” asset class, strategies can determine the subgroups. The following is a list of nine of the more familiar hedge fund strategies.

1. Convertible arbitrage commonly involves buying undervalued convertible bonds, preferred stock, or warrants, while shorting the underlying stock to create a hedge.
2. Distressed securities investments can be made in both debt and equity; because the securities are already distressed, shorting can be difficult or impossible.
3. Emerging markets generally only permit long positions, and often there are no derivatives to hedge the investments.
4. Equity market neutral (pairs trading) combines long and short positions in undervalued and over-valued securities, respectively, to eliminate systematic risk while capitalizing on mispricing.
5. Fixed-income arbitrage involves taking long and short positions in fixed-income instruments based upon expected changes in the yield curve and/or credit spreads.
6. Fund of funds describes a hedge fund that invests in many hedge funds to get diversification; there is a fee paid to the manager of the fund of funds, as well as to the managers of the funds in the fund of funds.
7. Global macro strategies take positions in major financial and non-financial markets through various means (e.g., derivatives and currencies), focusing on an entire group or area of investment instead of individual securities.
8. Hedged equity strategies (i.e., equity long-short) represent the largest hedge fund classification in terms of assets under management. These strategies take long and short positions in under- and over-valued securities, respectively. Hedged equity strategies do not focus on balancing the positions to eliminate systematic risk and can range from net long to net short.

9. Merger arbitrage (i.e., deal arbitrage) focuses on returns from mergers, spin-offs, takeovers, and so on.

Another classification scheme divides hedge funds strategies into five general segments:

- 1) relative value, 2) event driven, 3) hedged equity, 4) global asset allocators, and 5) short selling.
1. Relative value strategies attempt to exploit price discrepancies through various long and short strategies and on the relative mispricing.
2. Event-driven strategies invest with a short-term focus on an event like a merger (merger arbitrage) or the turnaround of a distressed company (distressed securities).
3. Equity hedge entails taking long and short equity positions with varying overall net long or short positions and can include leverage.
4. Global asset allocators take long and short positions in a variety of both financial and non-financial assets.
5. Short selling takes short-only positions in the expectation of a decline in value.

LOS 31.q

The most common compensation structure of a hedge fund consists of an assets-under-management (AUM) fee of about 1% to 2% and an incentive fee of 20% of profits.

High water marks (HWMs) are typically employed to avoid incentive fee double-dipping. For example, each quarter the increase in value over the previous quarter is determined, and investors pay incentive and management fees accordingly. If the value of the fund is lower than the previous quarter, however, the manager receives only the management fee, and the previous high value of the fund is established as a HWM.

A lock-up period limits withdrawals by requiring a minimum investment period (e.g., one to three years), preventing sudden withdrawals that could force the manager to have to unwind positions.

Incentive fees are paid to encourage the manager to earn ever higher profits. There is some controversy concerning incentive fees because the manager should have goals other than simply earning a gross return.

LOS 31.r

A fund of funds (FOF) consists of approximately 10 to 30 hedge funds. The point is to achieve diversification, but the extra layer of management means an extra layer of fees. Often, an FOF offers more liquidity for the investor, but the cost is cash drag. Despite the drawbacks, FOF are *good entry-level investments* because the manager of the FOF exercises due diligence.

An FOF may serve as a better *benchmark* because it suffers from less survivorship bias.

An FOF can suffer from style drift. Often two FOF that are classified as having the same style have a low correlation of returns.

FOF returns have been more highly correlated with equity markets than those of individual hedge funds. This characteristic has important implications for their use as a diversifier in an equity portfolio (i.e., as correlation increases, diversification decreases).

LOS 31.s

One special issue is that some claim that hedge funds are absolute-return vehicles, which means that no direct benchmark exists. The question (and problem) is how to determine alpha. Conventions to consider in hedge fund performance evaluation are the impact of performance fees and lock-up periods, the age of funds, and the size of funds.

- Funds with longer lock-up periods tend to produce higher returns than those with shorter lock-up periods.
- Younger funds tend to outperform older funds.
- Large funds underperform small funds.

By convention, hedge funds report monthly returns by comparing the ending value of the fund to the beginning value. These simply-calculated monthly returns are then compounded to arrive at annual returns. The convention for dealing with leverage is to treat an asset as if it were fully paid for. When derivatives are included, the same principle of deleveraging is applied.

Using standard deviation to measure the risk of a hedge fund can produce misleading results. Hedge fund returns are usually skewed with significant leptokurtosis (fat tails), so standard deviation fails to measure the true risk of the distribution.

Downside deviation is a popular hedge fund risk measure, as it measures only the dispersion of returns below some specified threshold return. The most common formula for downside deviation is:

$$\text{downside deviation} = \sqrt{\frac{\sum_{t=1}^n [\min(\text{return}_t - \text{threshold}, 0)^2]}{n-1}}$$

The threshold return in the formula is usually either zero or the risk-free rate of return. Annual hedge fund Sharpe ratios are calculated using annualized measures as:

$$\text{Sharpe}_{\text{HF}} = \frac{\text{annualized return} - \text{annualized risk-free rate}}{\text{annualized standard deviation}}$$

The Sharpe ratio has the following limitations with respect to hedge fund evaluation:

- *Time dependency.* Annualized Sharpe ratios are biased upwards by a factor of the square of time.
- *Assumes normality.* Measures that incorporate standard deviation are inappropriate for skewed return distributions.
- *Assumes liquidity.* Illiquid holdings have upward-biased Sharpe ratios (i.e., downward-biased standard deviations).
- *Assumes uncorrelated returns.* Returns correlated across time will artificially lower the standard deviation.
- *Stand-alone measure.* Does not automatically consider diversification effects.

LOS 31.t

CTAs that specialize in systematic trading strategies typically apply sets of rules to trade according to or contrary to short-, intermediate-, and/or long-term trends. A discretionary CTA trading strategy generates returns on the managers' trading expertise, much like any active portfolio manager. CTAs can also be classified according to whether they trade in financial markets, currency markets, or diversified markets.

The primary benefit to managed futures is superior risk-adjusted performance and diversification, although the performance seems to be related to specific strategies and time periods. Private funds seem to add value; publicly traded funds have performed poorly both stand-alone and in portfolios. Even though CTAs often exhibit negative correlations with equities, correlations among CTAs themselves can range from significantly to modestly positive. The CTA beta (relative to other CTAs) can be a good indicator of future risk-adjusted performance.

LOS 31.u

- Long-only value investing attempts to find opportunities where the prospects will improve tries to find them before other investors do. *High-yield investing* is buying publicly traded, below-investment grade debt. *Orphan equities investing* is the purchase of the equities of firms emerging from reorganization.
- Distressed debt arbitrage is the purchasing of a company's distressed debt while short selling the company's equity. The investment can earn a return in two ways:
 - ♦ If the firm's condition declines, the debt and equity will both fall in value, but equity should decline more in value.
 - ♦ If the company's prospects improve, the returns to bondholders should be greater than that of equity holders.
- Private equity is an "active" approach where the investor acquires positions in the distressed company, and the investment gives some measure of control. The investor can then influence the company as well as acquire more ownership in the process of any reorganization.

LOS 31.v

Distressed securities can have several types of risk:

- Event risk refers to the fact that the return on a particular investment within this class typically depends on an event for the particular company. Because these events are usually unrelated to the economy, they can provide diversification benefits.
- Market liquidity risk refers to low liquidity and the fact that there can be cyclical supply and demand for these investments.
- Market risk from macroeconomic changes is usually less important than the first two types mentioned.
- J-factor risk refers to the unpredictable nature of bankruptcy court judges' rulings.

CONCEPT CHECKERS

1. All of the following are special issues for the private wealth client when investing in alternative investments except:
 - A. tax issues.
 - B. decision risk.
 - C. return enhancement.
2. Which of the following represent private equity subgroups where the company invested in has not typically started generating revenues?
 - A. Start-up companies only.
 - B. Start-up companies and middle-market private companies only.
 - C. Start-up companies, middle-market private companies, and private investment in public entities only.
3. The hedge fund structure and private equity fund structure are subgroups of which alternative investment class?
 - A. Real estate.
 - B. Commodities.
 - C. Distressed debt.
4. The strategies of convertible arbitrage, emerging markets, equity market neutral, and fixed-income arbitrage are categories of which alternative investment class?
 - A. Real estate.
 - B. Hedge funds.
 - C. Commodities.
5. For use in evaluating hedge funds, the Sharpe ratio may not be appropriate because the Sharpe ratio assumes the returns:
 - A. are positive only.
 - B. reflect diversification.
 - C. are serially uncorrelated.
6. Based on historical data, when compared to a 50/50 stock/bond portfolio, a 40/40/20 portfolio of bonds, stocks, and which of the following had a higher Sharpe ratio?
 - A. Real estate only.
 - B. Commodities only.
 - C. Both real estate and commodities.
7. When comparing the returns of various types of hedge funds to the returns on stocks and bonds for the period 1990–2004:
 - A. none outperformed stocks and bonds by any measure.
 - B. some outperformed stocks and bonds and some did not.
 - C. all outperformed stocks and bonds on a risk-adjusted basis.

8. Compared to an indirect investment in real estate, a direct investment in real estate has which one of following advantages?
 - A. Lower commissions.
 - B. Lower information cost.
 - C. Potential for more leverage.
9. The buyers of venture capital who are the first investors after the entrepreneur's family and friends would *most likely* be:
 - A. vultures.
 - B. angel investors.
 - C. corporate venture capitalists.
10. Purchasing of a company's distressed debt while selling the company's equity short is called:
 - A. market neutral.
 - B. preferred arbitrage.
 - C. distressed debt arbitrage.

ANSWERS – CONCEPT CHECKERS

1. C Return enhancement is certainly not a special issue. All the other choices are issues of concern for the private wealth client but generally not issues for the institutional client.
2. A Start-up companies, middle-market private companies, and private investment in public entities represent three subgroups of private equity. Middle-market private companies typically have revenues, as do public entities. The start-up companies are usually in a pre-revenue phase.
3. C Investments in distressed debt can have either of these structures; that is why distressed debt is often considered as a subclass of other alternative investment asset classes.
4. B Hedge funds have many strategies that include the following: convertible arbitrage, distressed securities, emerging markets, equity market neutral, fixed-income arbitrage, fund of funds, global macro strategies, hedged equity strategies, and merger arbitrage.
5. C The Sharpe ratio is probably not applicable to hedge funds because it assumes the returns are normally distributed and not serially correlated. Another problem is that the Sharpe ratio is a stand-alone measure and does not consider the diversification that the hedge fund can add to a portfolio.
6. C As is the case with most of the classes of alternative investments, adding either real estate or commodities to a bond and stock portfolio would have increased the Sharpe ratio for the period 1990–2004.
7. B The performance of the various classes varied widely, from a Sharpe ratio of -0.25 for the short selling strategies to 1.51 on global macro strategies.
8. C Higher information costs, higher commissions, and political risk are disadvantages of direct investment in real estate. Direct investment allows more leverage, however.
9. B Angel investors are usually accredited investors and the first outside investors after the family and friends of the company founders.
10. C This is the definition of distressed debt arbitrage.

SWAPS

Study Session 13

EXAM FOCUS

While derivative strategies and usage are important topics for the Level III exam, this is an odd topic assignment. It is very short, has only one LOS, and includes a great deal of material marked as optional (not directly related to the LOS).

COMMODITY SWAPS, USE, AND RISK

LOS 32: Evaluate commodity hedging strategies that rely on swaps and describe their inherent risk exposures.

CFA® Program Curriculum, Volume 5, page 130

For the Exam: The LOS could be interpreted as requiring the calculation of the price and subsequent value of a commodity swap. That is covered here, and it also provides the basis to understand the risks in a commodity swap. The risks will be credit risk, the risk of changes in the underlying commodity price, and changes in interest rates. Understand the calculations covered and the risks created in varying situations.

Commodity Swap Price

Consider a company that needs 10,000 barrels of oil in one and two years and that wishes to hedge against price changes in oil. The company could buy 1- and 2-year contracts on oil at forward prices of \$95 and \$97, respectively. Alternatively, the company could enter a 2-year swap to receive oil. The swap price would be a single price for both settlement dates and a kind of present value average of the forward prices.

If the 1- and 2-year spot rates are 2.0% and 2.2%, the single swap price (SP) must have the same present value as the two forward prices.

$$\frac{\$95}{1.02} + \frac{\$97}{1.022^2} = \$186.01 = \frac{SP}{1.02} + \frac{SP}{1.022^2}$$

$$SP = \$95.99$$

Alternatively, the swap price can be expressed and solved as the sum of the present values of the forward prices divided by the sum of the present value factors used in the numerator. The present value factors at 1- and 2-year rates of 2% and 2.2% are just the reciprocals of 1.02 and 1.022² or 0.9804 and 0.9574 respectively. The present value factors could also be referred to as the present value of a dollar or yen or any other

currency. They could also be called the price of a zero-coupon bond with a face value of one currency unit. In the following formula they are denoted as FDF_t for the forward discount factor corresponding to time period t .

For a commodity swap the *swap price* is:

$$\text{swap price} = \frac{\sum_{t=1}^T (FDF_t) \times (\text{forward price of commodity})_t}{\sum_{t=1}^T FDF_t}$$

Resolving for the swap price we get:

$$[\$95(0.9804) + \$97(0.9574)] / [0.9804 + 0.9574] = \$95.99$$

A similar formula is used to price interest rate swaps:

$$\text{swap rate} = \frac{\sum_{t=1}^T (FDF_t) \times (\text{forward rate})_t}{\sum_{t=1}^T FDF_t}$$

The difference between the commodity swap and the interest rate swap is that in an interest rate swap the underlying “commodity” is interest rates. Hence the interest rate swap’s value is exposed to the risk of changing interest rates while the commodity swap is at risk to both changes in interest rates and the commodity price.

Commodity Swap Structure and Risks

It is important to notice that the swap price is not a simple arithmetic average of forward prices because implicit in the swap structure is that a loan is being made or received on each settlement date. In our example, the swap price was \$95.99 and not the simple average of \$95 and \$97 for \$96. Suppose in our example the forward prices correctly reflect what happens to spot prices over time: in one year oil is \$95, and the contract buyer paid the simple average of \$96. The buyer overpays \$1, effectively loaning \$1 to the oil seller. Then in two years if spot oil is \$97, the buyer underpays for oil at the contract price of \$96, receiving back the overpayment of \$1. An interest free loan is not rational, and by setting the contract price at 95.99, the oil buyer overpays (lends) \$0.99 and then underpays (receives back on the loan) \$1.01. The \$0.02 reflects interest on the loan. But the implicit loan created by using a single swap price on each settlement date creates interest rate risk. The \$0.02 was proper interest compensation based on initial interest rates. If rates change there can be a winner and loser on the implicit loan.

The structure of the swap can significantly affect the amount and kind of risks. The company could enter into a **prepaid swap** by paying a counterparty \$186.01 today and then receiving oil at the settlement dates in one and two years. However, this is excessively risky and creates unnecessary *credit risk* and *interest rate risk* for the company.

The company has paid up-front and is at risk if the counterparty does not deliver the oil. Also, a large sum has been advanced, effectively making a large fixed-rate loan.

The swaps market more typically uses *physical or financial settlement* on each exchange date for the swap. With physical settlement, the company will pay for and receive oil on each settlement date for the contracted delivery amount (notional amount) at the contracted price. With financial settlement, the company will settle in cash for any difference in the spot price of oil and the swap price on each settlement date. In both cases, the credit risk is reduced to the current value of the swap and is much smaller than the total present value paid at initiation of a prepaid swap. No large sum is advanced at initiation of the swap.

For both physical and financial swaps the initial value is zero. The swap is contracted at an average of forward prices. The initial value is zero, based on initial market conditions where neither the buyer nor the seller has any initial advantage. Our example also illustrates why the value of the swap will change immediately after initiation if either commodity prices or interest rates change because both affect the swap price.

Risk Factors for a Swap Dealer

Suppose the counterparty to our original swap is a swap dealer. The dealer is contracting to sell oil to our company at \$95.99. The dealer could find a *matched book swap* with another counterparty to buy oil at (for example) \$95.90. In this back-to-back set of transactions the dealer has two counterparty risks with credit exposure to both counterparties if they do not honor the swap's terms, but is fully hedged against changes in the price of the commodity and interest rates. The dealer has contracted to receive oil at \$95.90 and deliver oil at \$95.99, earning a bid-asked spread on each exchange date of \$0.09.

But suppose the dealer cannot find a willing counterparty at a reasonable price for the offsetting swap. The dealer can buy oil in the forward market for \$95.00 in one year and \$97.00 in two years. This hedges the dealer against changes in the price of oil, but the dealer is entering an implicit loan in the process. In one year, the dealer delivers oil at \$95.99 versus paying \$95.00 on the forward contract, the dealer pockets (borrows) \$0.99. In two years the dealer again receives \$95.99 on the swap and pays \$97.00 on the forward contract, effectively paying back \$1.01 on the loan, with \$0.02 the interest. As interest rates change that interest charge may become attractive or unattractive.

The point is that the dealer who used forwards to hedge the swap has two credit risk exposures to two counterparties (or more if each forward has a different counterparty), a small amount of interest rate risk from the implicit loan, and is hedged against a change in price of the commodity. If the dealer uses back-to-back swaps the dealer only has two counterparty risks.

Valuing Swaps

To summarize:

- The initial value of a physical or financial swap is zero because it is a present value reflection of forward prices. It is a fair price that both counterparties will willingly enter with no initial exchange of funds.
- The swap value will change as interest rates and underlying commodity prices change.
- Even if interest rates and commodity prices do not change, value of the swap will change as settlements occur and one or the other counterparty is making or receiving an implicit loan due to the single swap price used versus the varying forward prices for different settlement dates.
- The value of a commodity swap on any date can be computed as the present value of the settlement cash flows that can be locked in by taking offsetting positions in a new swap whose price reflects new forward contract prices.

For example, suppose in 3 months a new oil swap settling in 9 and 21 months (dates that match the settlement dates for our original 2-year swap, which are now in 9 and 21 months) is priced at \$97 versus our original swap's price of \$95.99. The company that entered the original swap to pay \$95.99 could enter this new swap to receive \$97. The company now has back-to-back swaps and has locked in the receipt of \$1.01 in 9 and 21 months. If 9- and 21-month annual interest rates are 3.0% and 3.5%, respectively, the value of the initial swap is now:

$$\$1.01 / 1.03^{0.75} + 1.01 / 1.035^{1.75} = \$1.9388 \text{ per barrel of oil}$$

Abusing Swaps, Enron

After the collapse of Enron in 2001, it subsequently became apparent it had used swap like transactions to create and hide large borrowing activity. Enron entered into the equivalent of prepaid swaps and received the present value of the forward prices. Enron then hedged the physical commodity exposure and contracted to make payments in the future. Exposure to the underlying commodity was hedged but Enron constructively borrowed large sums. Further confusing the real nature of the activity was the involvement of a supposed "third party" in the transactions, but in reality the third party was controlled by the bank with which Enron was contracting. The results were the nature of the transactions was hidden, the debt was not disclosed, and "profits" from use of the loans were reported as operating activities (not financial related activities). Investors were not able to judge the true riskiness of Enron until after its failure.

Swap Pricing in Seasonal Markets



Professor's Note: The next section after this Professor's Note is pretty far removed from the LOS. In the CFA text it receives just over one page of discussion with no end of chapter questions. Formulas are shown but never used and no math is illustrated. We are intentionally restricting our discussion to the concept. If you wish to look at the formulas they are available in the CFA text.

It is certainly plausible that an oil buyer might have a greater need for oil in certain seasons of the year. For example, the buyer may want the swap to specify larger quantities delivered in the winter and smaller quantities delivered in the summer. The basic commodity swap pricing approach can be modified for varying quantity by settlement date. Recall the single swap price is a present value average of forward prices. For a varying quantity swap, the forward prices would be the present value weighted by the varying quantity. For example, the winter price might be multiplied by 50 barrels and the summer price by 30 barrels.

The varying quantity swap could also allow for different prices on different delivery dates. First, the single swap price for a varying quantity swap would be found as discussed in the preceding paragraph. The summer and winter prices must be a present value weighted average of this number. Second, the desired summer (or winter) price is then arbitrarily selected, and then the winter (or summer) price is solved for such that the weighted present value of the two prices is the same as the weighted present value for the single price swap.

KEY CONCEPTS

LOS 32

The prepaid swap buyer pays the present value of forward prices upfront and has (1) substantial *credit risk* that the other counterparty will not deliver the commodity, (2) *financial or interest rate risk* because a large amount has been advanced at swap initiation, and (3) the *market price risk* as spot and forward prices change in such a way that the prepaid price was too high or too low.

For financially and physically settled swaps there is still market price risk from the changes in price of the underlying commodity. But interest rate and credit risk are considerably less as no upfront payment is made. At inception, the credit risk to both parties is zero. The credit risk can go back and forth between the counterparties during the life of the swap as the value of the swap changes.

A swap dealer who hedges a swap with a back-to-back swap has two swaps and two counterparty (potential credit) risks but is hedged for market and interest rate risk. The dealer who hedges using forwards also has two credit risk exposures and some interest rate risk due to the implicit loans made or received, but is hedged for market price risk.

Swaps can be priced with varying seasonal quantity and/or price by including a varying quantity and/or price component into the swap agreement.

CONCEPT CHECKERS

1. At inception, the value of a commodity swap is typically:
 - A. zero.
 - B. less than zero.
 - C. greater than zero.
2. With respect to swap rates for interest rate swaps and swap prices for commodity swaps, which are weighted averages based upon forward contracts?
 - A. Swap rates only.
 - B. Swap prices only.
 - C. Both swap rates and swap prices.
3. A change in interest rates and forward rates will affect the value of:
 - A. commodity swaps only.
 - B. interest rate swaps only.
 - C. both interest rate swaps and commodity swaps.
4. Being able to vary the notional principal of a commodity swap in a swap contract is:
 - A. both possible and legal.
 - B. not possible but would probably be legal.
 - C. not possible and would be illegal if possible.

Use the following information for Questions 5 and 6.

Concerned with global supply issues, a supply manager wants to hedge future purchases of crude oil that his firm will use in manufacturing solvents estimated to be 1,200,000 barrels in each year. Current forward prices for delivery of crude in one and two years are \$125.88 and \$129.01, respectively. The current 1-year and 2-year Treasury rates are 2.38% and 2.63%, respectively. The manager approaches a swap dealer to enter (strike) a 2-year swap agreement.

5. Based on current forward prices and interest rates, the fixed price for a 2-year crude oil swap is *closest* to:
 - A. 125.44.
 - B. 127.42.
 - C. 128.22.
6. If at the first settlement date in one year the spot price of crude is \$127.96, what would the *most likely* settlement action be? The manager will:
 - A. make a payment of \$312,000.
 - B. receive a payment of \$550,000.
 - C. receive a payment of \$648,000.

ANSWERS – CONCEPT CHECKERS

1. A The swap price is designed to make the value of the swap zero at inception.
2. C Both swap rates and swap prices are weighted averages based upon forward discount factors, or equivalently, zero-coupon bond prices.
3. C Because the value of both types of swaps is the present value of a locked-in set of cash flows, the value of both types of swaps is sensitive to changes in interest rates.
4. A Swap counterparties can design the swap any way they choose. Commodity swaps can have the quantity and swap price change over the life of the swap.
5. B The swap fixed price is the present value of the forward prices using the 1- and 2-year interest rates:

$$\text{swap price} = \frac{\frac{125.88}{1.0238} + \frac{129.01}{(1.0263)^2}}{\frac{1}{1.0238} + \frac{1}{(1.0263)^2}} = 127.42$$

6. C The manager will purchase the oil in the spot market, and because the spot price is above the swap fixed price, the manager will receive a payment from the dealer. If the spot price had instead been below the swap fixed price, the manager would have to make a payment to the dealer.



Professor's Note: The final amount paid for the commodity should be the swap fixed price, so I recommend checking that if you are asked for this on the exam.

$$\begin{aligned} \text{settlement payment} &= (\text{spot price} - \text{swap fixed price}) \text{NP} \\ &= \left[\left(\$127.96 / \text{barrel} \right) - \left(\$127.42 / \text{barrel} \right) \right] \times 1,200,000 \text{ barrels} = \$648,000 \end{aligned}$$

Check:

Purchase 1.2 million barrels in the spot market:

$$\$127.96 \times 1,200,000 = \$153,552,000$$

Receive swap settlement of \$648,000:

$$\text{net per barrel} = \frac{\$153,552,000 - \$648,000}{1,200,000} = \$127.42$$

COMMODITY FORWARDS AND FUTURES

Study Session 13

EXAM FOCUS

There are two important and related comments found in the introductory CFA material to this section that are overlooked by many candidates. They are important to what you will and will not find in this material. First, “each commodity forward ... has some unique economic characteristics.” Second, “it would take an entire book to cover commodities in depth”. The explicit goal of this section is to cover the logic of the factors that may or may not apply to a given commodity. It will not “tie it up” in one comprehensive conclusion. Consistent with the LOS, focus on the concepts and implications of lease rates, storage costs, and convenience yields. Be able to make a direct calculation of a forward price and convenience yield.

PRICING COMMODITY FORWARDS AND FUTURES

LOS 33.a: Discuss pricing factors for commodity forwards and futures, including storability, storage costs, production and demand, and explain their influence on lease rates and the forward curve.

CFA® Program Curriculum, Volume 5, page 159

Commodity and financial forward contracts are similar in some regards. For example, the prices of both are logically based upon expected spot prices. Some financial forwards (e.g., S&P 500 Index) are based upon the expected future spot price minus dividends received during the holding period. The price of a commodity forward must also be based upon expectations, but there are several factors to consider.

- Some commodities, like metals, are easily storable allowing the cash-and-carry no-arbitrage mode studied at Level II to be applied. Other commodities like perishable foods are not storable which will restrict the application of cash-and-carry.
- Unlike stocks and bonds, there are significant storage costs to holding and safeguarding commodities.
- Some commodities have distinct seasonal or other production (supply) or demand patterns (for example, corn, electricity, and oil) that affect future spot and current forward prices.
- Some commodities are also appropriate for *leasing*.

Where applicable, the forward price of a commodity must reflect these factors.

Lease Rates

An investor without a current need for the commodity could buy it and lend it out to others who do have a current need. The borrower of the commodity would compensate the commodity lender with a payment. Because the commodity buyer has funds invested in the commodity, he must charge a lease rate. Failing to do so would amount to an interest-free loan of the money tied up in the commodity.

A *lease rate*, δ_l , is the amount of interest a lender of a commodity requires. The lease rate is defined as the return an investor requires to buy and then lend a commodity. From the borrower's perspective, the lease rate represents the cost of borrowing the commodity. Unlike a dividend, the lease rate is not directly observable. The commodity does not declare a lease rate. In addition, all holders of a stock earn the dividend but the lease rate of a commodity can only be earned if the commodity owner chooses to lend it out. Financially, the lease rate functions just like a dividend and is modeled like a dividend in order to price commodity forwards. Both the lease rate and risk-free rate are important inputs to determining a commodity forward price.

A no-arbitrage price can be calculated using the approach taught at Level II with the lease rate substituting for the dividend yield. Given the annual lease rate, risk-free rate, spot price of the commodity, and term of the forward, the no-arbitrage forward price will be:

$$F_{0,T} = S_0 e^{(R_F - \delta_l)T}$$

where:

S_0 = commodity current spot price

$R_F - \delta_l$ = risk-free rate less the lease rate

T = the term is the fraction of a year to contract expiration

Example: Effect of lease rate

An investor wants exposure to a commodity. The investor could buy and hold the physical commodity or buy forwards. Assume there is an active lease rate for the commodity, all factors are correctly reflected in spot and forward prices, and the investor would not find it practical to lease the commodity. How should the investor add commodity exposure to the portfolio?

Answer:

Buy the commodity forward. Because the relative prices reflect leasing and the investor cannot earn the lease rate, buying the commodity would be overpaying because there is an expected return component the investor will not earn. All other factors are correctly reflected in the difference between the spot and forward prices.

Example: Pricing a commodity forward with a lease payment

Calculate the 12-month forward price for a bushel of corn that has a spot price of \$5 and an annual lease rate of 7%. The appropriate continuously compounding annual risk-free rate for the commodity is equivalent to 9%.

Answer:

We can determine the 12-month forward price as follows:

$$F_{0,T} = (S_0)e^{(R_F - \delta_1)T} = \$5 \times e^{(0.09 - 0.07)(1)} = \$5.101$$

Because the lease rate is not directly observable, it is more common to rearrange the forward pricing formula to infer the lease rate from observed market prices. The annualized implied lease rate is:

$$\delta_1 = R_F - \frac{1}{T} \ln \left(\frac{F_{0,T}}{S_0} \right)$$

Example: Solving for the lease rate.

Calculate the annualized lease for the previous example if the forward price is \$5.101:

Answer:

We can determine the 12-month lease rate as:

$$\text{Lease rate} = 0.09 - \frac{1}{1} \ln \left(\frac{5.101}{5} \right) = 0.09 - \ln 1.2020 = 0.09 - 0.02 = 0.07 = 7.0\%$$

The Shape of the Forward Curve and the Lease Rate

If there are no other factors to consider:

- The forward market will be in *contango* (an upward sloping price curve with longer maturity contracts priced above shorter maturity contracts which are priced above the spot price) when the lease rate is less than the risk-free rate.
- The forward market will be in *backwardation* (a downward sloping price curve with longer maturity contracts priced below shorter maturity contracts which are priced below the spot price) when the lease rate is greater than the risk-free rate.



Professor's Note: This is a simple consequence of the arbitrage based forward pricing formula. A lease rate (or dividend) on the underlying increases the relative value of owning the underlying spot asset and reduces the forward price, while the risk-free rate increases the financing cost to buy the underlying and makes the relative value of the spot asset less and raises the forward price.

Storage Costs

The same arbitrage based forward pricing formula can also incorporate storage costs, which are treated mathematically like the risk-free financing rate. Unlike stocks and bonds which have essentially zero storage costs, holding physical commodities will require a physical location to store the commodities and insure them against loss. The arbitrageur who buys the spot commodity and sells it at the forward price is conducting a *cash-and-carry* because he pays cash but must store (i.e., carry) the commodity until the delivery date. The owner will only store the commodity if the forward price is greater than or equal to the expected spot price plus storage costs. This is represented mathematically as:

$$F_{0,T} \geq S_0 e^{R_F T} + \lambda(0, T)$$

where:

$\lambda(0, T)$ = future value of storage costs from time 0 to T

If storage costs are paid continuously and are proportional to the value of the commodity, then the no-arbitrage forward price becomes:

$$F_{0,T} \geq S_0 e^{(R_F + \lambda)T}$$

where:

λ = continuous annual storage cost proportional to the value of the commodity

Example: Commodity forward pricing with storage costs and effective interest

Calculate the 3-month forward price for a bushel of soybeans if the current spot price is \$3/bushel, the effective monthly interest rate is 1%, and the monthly storage costs are \$0.04/bushel.

Answer:

First, calculate the future value (at time T) of storage for three months, $\lambda(0, T)$, as follows:

$$\$0.04 + \$0.04(1.01) + \$0.04(1.01)^2 = \$0.1212$$

The amount \$0.1212 represents three months' storage costs plus interest. Next, add the cost of storage to the spot price plus interest on the spot price:

$$\begin{aligned} F_{0,T} &= S_0 e^{R_F T} + \lambda(0, T) \approx \$3.00(1.01)^3 + \$0.1212 \\ &= \$3.0909 + \$0.1212 = \$3.2121 \end{aligned}$$

Example: Commodity forward pricing with storage costs and continuously compounded interest

Now assume that storage costs are paid continuously and are stated as a percent of the cost of the commodity. Calculate the 3-month forward price for a bushel of soybeans if the current spot price is \$3/bushel, the continuously compounded annual interest rate is 12%, and the continuously compounding annual storage costs proportional to the value of the commodity is \$0.48/bushel or 16%.

Answer:

The 3-month forward price is:

$$F_{0,T} = S_0 e^{(R_F + \lambda)T} = \$3 e^{(0.12 + 0.16)(3/12)} = \$3 e^{0.07} = \$3.218$$

Convenience Yield

If the owners of the commodity need the commodity for their business, holding physical inventory of the commodity creates value. For example, assume a manufacturer requires a specific commodity as a raw material. In order to reduce the risk of running out of inventory and slowing down production, excess inventory is held by the manufacturer. This reduces the risk of idle machines and workers. A *convenience yield* is a non-monetary benefit associated with holding the commodity and can only be earned by those with an underlying business reason to hold the commodity. While it functions like a non-monetary dividend, it has an asymmetric impact on the no-arbitrage forward price:

- An arbitrageur who wishes to borrow the underlying commodity and sell it for a reverse cash-and carry must compensate the lender of the commodity for lost convenience yield. Inserting the convenience yield in the no-arbitrage pricing formula generates a minimum forward price.
- An arbitrageur who wishes to buy the underlying commodity for a cash-and-carry has no convenience yield to factor in. Ignoring the convenience yield creates a maximum forward price.

For the Exam: The CFA text is quite specific that it will not provide a final comprehensive solution to all commodity pricing issues. Instead, the intent is to illustrate some of the complexities of commodity contract pricing. In relation to convenience yield it includes a footnote that not all market participants define it the same way. Regarding the lease rate, the CFA text makes two points:

- Prior to considering the convenience yield, the lease rate is defined as the negative of the storage costs.
- After considering the convenience yield, the lease rate is defined as the convenience yield minus storage costs.

Both statements are true, it is a matter of whether or not it is relevant to consider convenience yield.

Here is a handy guide for relating relative forward and spot commodity prices:

- Higher risk-free rates are a benefit of owning the forward as financing costs to hold the underlying commodity are avoided. In the pricing formula, R_f pushes up the relative price of the forward versus the spot price.
- Higher storage costs are a benefit of owning the forward as storage costs to hold the underlying commodity are avoided. In the pricing formula, λ pushes up the relative price of the forward versus the spot price.
- Higher lease rates are a cost of owning the forward as they are a lost opportunity that can only be earned by someone who owns the underlying commodity. In the pricing formula $-\delta$ reduces the relative price of the forward versus the spot price.
- Higher convenience yields are a cost of owning the forward as they are a lost opportunity that can only be earned by someone who has a business reason to own the underlying commodity. In the pricing formula, $-c$ reduces the relative price of the forward versus the spot price. It is a factor in reverse cash-and-carry but not in cash-and-carry which results in a no-arbitrage range, rather than a single no-arbitrage price.

Of course, there can be combinations of costs and benefits where a calculation is required:

$$F_{0,T} = S_0 e^{(R_f + \lambda - c)T}$$

where:

λ = the storage costs

c = the convenience yield

And

$$F_{0,T} = S_0 e^{(R_f - \delta)T}$$

where:

δ = lease rate



Professor's Note: The lease rate (δ) compensates the lender for the loss of the convenience yield less storage costs, so $\delta = c - \lambda$.

COMMODITY CHARACTERISTICS

Certain commodities exhibit unique properties that impact their forward prices. For example, gold, corn, natural gas, and oil are all examples of commodities with characteristics that differ with respect to storage costs, the ability to store, production costs, and seasonal supply and demand. These differences are reflected in lease rates, storage costs, and convenience yields that influence the commodity forward prices and the shape of the forward curves. The next sections illustrate how various combinations of these and other factors may affect particular commodity markets.

Gold Forward Price Factors

Because gold can earn a return by lending it out, strategies for holding synthetic gold offer a higher return than holding just the physical gold without lending it out. When a positive lease rate is present, the synthetic gold is preferred to physically holding the gold because the lease rate represents the cost of holding the gold without having to lend it physically. In other words, by holding physical gold you sacrifice the lease rate and you incur storage costs.

The value of gold is also influenced by the costs of production. The present value of gold received in the future is simply the present value of the forward price computed at the risk-free rate of return. The total present value of gold production (i.e., the value of the gold mine) is calculated as:

$$\text{total PV of production} = \sum_{i=1}^n X_i (F_{0,i} - c_{p,i}) e^{-(R_{F,i})t_i}$$

where:

X_i = ounces of gold extracted (produced) in period i

$F_{0,i}$ = forward price today for delivery of one ounce at the end of period i

$c_{p,i}$ = production costs per ounce in period i

$R_{F,i}$ = risk-free rate over period i

Under this framework, the gold mine is assumed to operate the entire time and production is known with certainty.



Professor's Note: Nothing in the LOS suggest you should memorize specific calculations shown in the various commodity markets. These are to illustrate how varying factors come into play for particular commodities. Gold is presented here only to show how production costs affect values. Note that the costs associated with mining gold are incorporated into the forward price, much like a storage cost.

Corn Forward Price Factors

Corn is an example of a commodity with seasonal production and a constant demand. Corn is produced in the fall of every year, but it is consumed throughout the year. In

order to meet consumption needs, corn must be stored. Thus, interest and storage costs need to be considered. The price of the corn will fall as it is being harvested and then rise to reflect the cost of storage until it is harvested again. Thus, the forward curve increases until harvest time, then drops sharply at harvest time and slopes upward again when the harvest is over.

Example: Corn commodity pricing with storage costs

Suppose the spot price today for a bushel of corn is \$2.25, the continuously compounded interest rate is 5.5%, and the storage cost is 2.0% per month. Calculate the 6-month forward price.

Answer:

$$F_{0,0.5} = \$2.25 \times e^{(0.00458 + 0.02)6} = 2.25 \times 1.15893 = \$2.61$$



Professor's Note: The 0.458% used for the monthly interest rate is the annual rate divided by 12.

Natural Gas Forward Price Factors

Natural gas is an example of a commodity with constant production but seasonal demand. Natural gas is expensive to store, and demand in the United States peaks during the winter months. In addition, the price of natural gas is different for various regions due to high international transportation costs. Storage is at its highest in the fall, just prior to the peak demand. Therefore, the forward curve rises steadily in the fall. The following example demonstrates how storage costs produce a positively sloped forward curve.

Example: Calculation of natural gas forward price with storage costs

Calculate the implied storage cost for natural gas for the month of October, if the October 2009 spot price is 4.071, the annual risk-free rate of interest is 6%, and the November forward price is 4.157.

Answer:

$$\$4.157 = \$4.071e^{0.005} + \lambda_{\text{Oct2009}}$$

$$\$4.157 = \$4.091 + \lambda_{\text{Oct2009}}$$

$$\$4.157 - \$4.091 = \lambda_{\text{Oct2009}}$$

$$\$0.066 = \lambda_{\text{Oct2009}}$$

Oil Forward Price Factors

The physical characteristics of oil make it easier than natural gas to transport; consequently, the price of oil is comparable worldwide. Lower transportation costs and more constant worldwide demand cause the long-run forward price to be fairly stable. In the short run, supply and demand shocks cause more volatile prices because supply is fixed. For example, the Organization of Petroleum Exporting Countries (OPEC) may decrease supply to increase prices by causing a shortage in the short run. Supply and demand adjust to price changes in the long run.

COMMODITY ARBITRAGE

LOS 33.b: Identify and explain how to exploit arbitrage situations that result from the convenience yield of a commodity and from commodity spreads across related commodities.

CFA® Program Curriculum, Volume 5, page 171

Convenience Yield

A convenience yield *cannot* be earned by the average investor who does not have a business reason for holding the commodity. The forward price, including a convenience yield and storage costs, is calculated:

$$F_{0,T} \geq S_0 e^{(R_F + \lambda - c)T}$$

where:

c = convenience yield

λ = storage costs

The commodity borrower (i.e., lessee) is willing to pay $\delta = c - \lambda$, which is the value of the convenience yield less the cost of storage. The value of the forward to the commodity borrower is calculated as follows:

$$F_{0,T} \geq S_0 e^{(R_F - \delta)T}$$

For the investor who does not earn the convenience yield, cash-and-carry arbitrage implies that:

$$F_{0,T} \leq S_0 e^{(R_F + \lambda)T}$$

Example: Impact of convenience yield on the no-arbitrage commodity forward pricing range

Suppose the owner of a commodity decides to lend it, and the commodity has a continuously compounded convenience yield of c . What range of prices must represent the no-arbitrage forward price?

Answer:

The owner of a commodity is able to create a range of no-arbitrage prices as follows:

$$S_0 e^{(R_F + \lambda - c)T} \leq F_{0,T} \leq S_0 e^{(R_F + \lambda)T}$$

The upper bound $(S_0 e^{(R_F + \lambda)T})$ depends on storage costs but not on the convenience yield. The lower bound $(S_0 e^{(R_F + \lambda - c)T})$ adjusts for the convenience yield and therefore explains why forward prices may appear lower at times, when a convenience yield is considered.

Arbitrage and Commodity Spreads

A *commodity spread* results from a commodity that is an input in the production process of other commodities. For example, soybeans are used in the production of soybean meal and soybean oil. A trader creates a *crush spread* by holding a long (short) position in soybeans and a short (long) position in soybean meal and soybean oil.

Similarly, oil can be refined to produce different types of petroleum products such as heating oil, kerosene, or gasoline. This process is known as *cracking* and, thus, the difference in prices of crude oil, heating oil, and gasoline is known as a *crack spread*. For example, seven gallons of crude oil may be used to produce four gallons of gasoline and three gallons of heating oil. Commodity traders refer to the crack spread as 7-4-3, reflecting the seven gallons of crude oil, four gallons of gasoline, and three gallons of heating oil. Thus, an oil refiner could lock in the price of the crude oil input and the finished good outputs by an appropriate crack spread reflecting the refining process. However, this is not a perfect hedge because there are other outputs that can be produced (such as jet fuel and kerosene).

Example: Pricing a crack (i.e., crude oil) spread

Suppose we plan on buying crude oil in one month to produce gasoline and heating oil for sale in two months. The 1-month futures price for crude oil is currently \$118/barrel. The 2-month futures prices for gasoline and heating oil are \$125/barrel and \$133/barrel, respectively. Calculate the 5-3-2 crack (commodity) spread.

Answer:

The 5-3-2 spread tells us the amount of profit that can be locked in by buying five barrels of oil and producing three barrels of gasoline and two barrels of heating oil.

Profit for a 5-3-2 spread = $(3 \times \$125) + (2 \times \$133) - (5 \times \$118) = \$375 + \$266 - \$590 = \$51$ for 5 barrels or $\$51 / 5 \text{ barrels} = \$10.20/\text{barrel}$.



Professor's Note: There is no calculation for interest adjustment in this example.

HEDGING AND BASIS RISK

LOS 33.c: Compare the basis risk of commodity futures with that of financial futures.

CFA® Program Curriculum, Volume 5, page 185

A perfect hedge rarely exists. A hedge can be perfect only if the item hedged and the hedging vehicle match exactly and the hedge is held to contract expiration. For example, a stock trades at \$21 today and can be sold today in the forward market at \$22 to settle in 6 months. If the stock is owned, sold forward, and delivered in 6 months, the hedge is perfect and the hedge locks in \$22, the forward price. The initial basis was the initial forward price minus the spot price of \$1.00. A perfect hedge will lock in:

- The initial forward price.
- The initial spot price plus basis.

When the hedge is imperfect, the results can be imperfect. The hedge might be lifted early if the term of the contract is longer than the desired term of the hedge, if the term of the contract is shorter than desired the contract might be rolled over into a new longer contract when the first contract comes due, or the contract may be based on something similar to but not the same as the item being hedged. In these cases the hedge may not achieve the initial forward price. In other words, the initial basis (difference between the forward and spot price) may change in unexpected ways, called *basis risk*. This issue exists for both commodity and financial futures (and forwards) but it tends to be greater in commodities. The complicating issues for commodity hedging include:

- Hedging an uncertain quantity. A producer of coal might sell estimated production forward but actual production and date of production could easily differ from what was expected and hedged, resulting in an imperfect hedge and basis risk.
- Commodities are heterogeneous, not homogeneous. A user of natural gas in Florida might purchase gas contracts to hedge the need for gas. However, the available contract specifies the price of gas in Louisiana, a different physical location. The prices in the two locations can differ and fluctuate in relation to each other due to the difficulty and cost of transporting gas between the two locations. In this example, there is basis and cross-hedge risk.

- Cross-hedging is common. An airline needing to hedge the price of jet fuel may find it more practical to purchase oil futures as a hedge. While oil and jet fuel prices are related, they can move in unexpected ways in any given time period. There is basis and cross-hedge risk.
- Contracts often trade in useable volume only for near-term expiration dates. Suppose a gold user needs the same quantity of gold every month for two years. The lowest risk solution is a **strip hedge**. The user would buy gold futures contracts coinciding with each date that gold is needed. However, trading volume may be insufficient to allow purchase on the longer dates. The user may have to use a **stack hedge** of shorter dated contracts instead of the longer dates. A stack hedge requires buying more of the shorter contracts than of the number of longer contracts that would have been needed. As the shorter contracts come due, they will be rolled over to the needed (and now closer) dates. The stack hedge is premised on the changes in present value in the larger number of shorter contracts being sufficient to fund the rollover purchases that will have to be made at the current market price. This results in basis risk.

Professor's Note: By now you should realize the exam process sometimes requires you to deal with issues without having seen or gone through all the underlying details and reading the material in context. Both of these issues are at work here.

First, the mechanics of strip and stack hedges are not covered in the material, only that stack hedges may be necessary due to a lack of liquidity for longer dated contracts; this creates some residual risk when the contracts are rolled over.



Second, the terms basis and cross-hedge risk are used many times in the CFA material and they are often used interchangeably. A cross-hedge is most correctly used to refer to a difference in the hedged item and the hedge vehicle (for example, hedging jet fuel with oil). Basis risk is the risk that the difference between the forward and spot prices change in unexpected ways. Both risks can be related. On the exam and in some readings, the two are used interchangeably. When you answer questions on the exam be as precise and technically correct as possible, but read exam questions and material in the context of what was written to infer what was meant. You may feel this is unfair, but it is part of the testing process.

KEY CONCEPTS

LOS 33.a

The lease rate is defined as the amount of return the investor requires to buy and then lend a commodity. If an active lease market exists for a commodity, a commodity lender can earn the lease rate by buying a commodity and immediately selling it forward. The commodity market is in contango with an upward-sloping forward curve when the lease rate is less than the risk-free rate. The market is in backwardation with a downward-sloping forward curve when the lease rate is greater than the risk-free rate.

A commodity owner will only store the commodity if the forward price is greater than or equal to the spot price plus the future storage costs as follows: $F_{0,T} \geq S_0 e^{R_F T} + \lambda(0, T)$, where $\lambda(0, T)$ represents the future value of storage costs for one unit of the commodity from time 0 to T. If storage costs are paid continuously and are proportional to the value of the commodity, the no-arbitrage forward price becomes $F_{0,T} = S_0 e^{(R_F + \lambda)T}$.

Holding an excess physical inventory of the commodity creates non-monetary value for commodity owners who require the commodity as a production input. This is referred to as convenience yield, and the forward price including a convenience yield is calculated as $F_{0,T} \geq S_0 e^{(R_F + \lambda - c)T}$, where c is the continuously compounded convenience yield, proportional to the value of the commodity.

Gold, corn, natural gas, and oil are all examples of commodities with characteristics that differ with respect to storage costs, the ability to store, production costs, and seasonal demand. These unique differences influence the commodity forward prices and the shape of the forward curves.

LOS 33.b

A commodity used in production has a convenience yield that would be earned by a user of the commodity with a business reason to hold the commodity. The result is a no arbitrage range for the forward price:

$$S_0 e^{(R_F + \lambda - c)T} \leq F_{0,T} \leq S_0 e^{(R_F + \lambda)T}$$

The upper bound $\left(S_0 e^{(R_F + \lambda)T} \right)$ depends on storage costs but not the convenience yield.

The lower bound $\left(S_0 e^{(R_F + \lambda - c)T} \right)$ adjusts for the convenience yield and, therefore, explains why forward prices may appear lower at times when a convenience yield is considered.

LOS 33.c

Basis is the difference between the spot price (or rate) and the price (or rate) of the futures contract used to hedge. If the values of both move together perfectly, an investor long or short the asset can lock in a return or value by selling or buying futures, respectively. Any time the values of the spot and futures contracts do not move together perfectly, however, the hedger faces basis risk (i.e., an uncertain basis). As with financial futures, every commodity futures contract specifies a delivery amount and a delivery date. In addition, however, every commodity futures contract specifies a delivery location and the deliverable grade (i.e., quality).

CONCEPT CHECKERS

- The spot price for a commodity is \$24. The annual lease rate is 6% for the commodity. The appropriate continuously compounding annual risk-free rate for the commodity is equivalent to 7%. The 6-month commodity forward rate is *closest* to:
 A. \$23.91.
 B. \$24.00.
 C. \$24.12.
- The current spot price for corn is \$3/bushel, the *effective* monthly interest rate is 1.5%, and the monthly storage costs are \$0.03/bushel. The 3-month forward price for a bushel of corn is *closest* to:
 A. \$3.18.
 B. \$3.23.
 C. \$3.29.
- Suppose that storage costs are paid continuously and are proportional to the cost of the commodity. Calculate the 3-month forward price for a bushel of corn if the current spot price is \$2.50/bushel, the continuously compounded annual interest rate is 10%, and the continuously compounded annual storage costs proportional to the value of the commodity are 14.4%. The 3-month forward price is *closest* to:
 A. \$2.55.
 B. \$2.66.
 C. \$2.73.
- Suppose the owner of a commodity decides to lend out the commodity. If the commodity has a continuously compounded convenience yield of c , proportional to the value of the commodity, which of the following *best* represents the lowest forward price?
 A. $S_0 e^{(R_F + \lambda)T}$.
 B. $S_0 e^{(R_F - \delta_1 - c)T}$.
 C. $S_0 e^{(R_F + \lambda - c)T}$.
- Suppose we plan on buying crude oil in one month to produce gasoline and heating oil for sale in two months. The 1-month futures price for crude oil is currently \$120/barrel. The 2-month futures prices for gasoline and heating oil are \$127/barrel and \$135/barrel, respectively. What is the 7-5-2 crack (commodity) spread?
 A. \$9.29/barrel.
 B. \$12.71/barrel.
 C. \$14.50/barrel.
- Which of the following is not an example of basis risk? Purchasing:
 A. a Eurodollar contract, due to lack of commodity futures.
 B. an oil contract with delivery in a different geographical region.
 C. a commodity with a desired distant delivery with long-term contracts.

7. Which of the following commodities is an example of seasonal production and constant demand?
- A. Gold.
 - B. Corn.
 - C. Natural gas.

ANSWERS – CONCEPT CHECKERS

1. C The 6-month forward rate is calculated as follows:

$$F_{0,T} = S_0 e^{(R_F - \delta)T} = \$24 \times e^{(0.07 - 0.06)0.5} = \$24.12$$

2. B First, calculate the future cost of storage for three months, $\lambda(0, T)$, as follows:

$$\$0.03 + \$0.03(1.015) + \$0.03(1.015)^2 = \$0.0914$$

The amount of \$0.0914 represents the 3-month storage costs plus interest. Next, add the cost of storage to the spot price plus interest.

$$F_{0,T} = S_0 e^{R_F T} + \lambda(0, T) \approx \$3.00(1.015^3) + \$0.0914 = \$3.1370 + \$0.0914 = \$3.23$$

3. B The 3-month forward price is:

$$F_{0,T} = S_0 e^{(R_F + \lambda)T} = \$2.50 e^{(0.10 + 0.144)3/12} = 2.50(1.0629) = \$2.657$$

4. C The owner of a commodity is able to create a range of no-arbitrage prices as follows:

$S_0 e^{(R_F + \lambda - c)T} \leq F_{0,T} \leq S_0 e^{(R_F + \lambda)T}$. The lower bound adjusts for the convenience yield and, therefore, explains why forward prices may appear lower at times when the convenience yield is considered. The upper bound depends on storage costs but not on the convenience yield.

5. A The 7-5-2 spread tells us the amount of profit that can be locked in by buying seven barrels of oil and producing five barrels of gasoline and two barrels of heating oil.

$$\text{Profit for a 7-5-2 spread} = (5 \times \$127) + (2 \times \$135) - (7 \times \$120) = \$635 + \$270 - \$840 = \$65 \text{ for 7 barrels, or } \$65 / 7 \text{ barrels} = \$9.29/\text{barrel}.$$

6. C Basis risk results from the inability of commodities to create a perfect hedge. Differences due to timing, grade, storage costs, or transportation costs create basis risk.

7. B Corn is an example of a commodity with seasonal production and a constant demand. Corn is produced in the fall of every year, but it is consumed throughout the year.

RISK MANAGEMENT

Study Session 14

EXAM FOCUS

Risk management is a key component of investment management. Without risk, reward is unlikely; too much risk, failure looms. Be able to compare an enterprise risk management (ERM) system to a decentralized system of risk management as well as evaluate an existing ERM system. Value at risk (VAR) is an important topic. Be able to calculate VAR using different methods, know the pros and cons of various methods, and discuss other tools to measure or manage risk (including credit risk).

The focus of this material is on an overall organization. How does an investment firm or other organization manage risk?

MANAGING RISK

LOS 34.a: Discuss the main features of the risk management process, risk governance, risk reduction, and an enterprise risk management system.

CFA® Program Curriculum, Volume 5, page 196

Investment managers should take necessary risks and those where they have information or another advantage in order to generate return. Other risks should be reduced, avoided, or completely hedged. Risk **reduction** refers to recognizing and reducing, eliminating, or avoiding those unnecessary risks.

The **risk management** process requires:

1. Top level management of the organization setting policies and procedures for managing risk.
2. Defining risk tolerance to various risks in terms of what the organization is willing and able to bear. For some risks tolerance will be high, for others it will be low.
3. Identifying risks faced by the organization. Those risks can be grouped as *financial* and *non-financial risks*. This will require building and maintaining investment databases for both types of risk.
4. Measuring the current levels of risk.
5. Adjusting the levels of risk—upward where the firm has an advantage and seeks to generate return to exploit an advantage, downward in other cases. As part of adjusting risk levels the firm must:
 - ♦ Execute transactions to change the level of risk using derivatives or other instruments.

- ♦ Identify the most appropriate transaction for any given objective.
- ♦ Consider the cost of any transaction.
- ♦ Execute each transaction.

The risk management process is ongoing, data and analysis must be continuously updated. Once a risk to the firm has been identified, it may be necessary to determine appropriate models to quantify the risk and or evaluate possible ways to adjust the risk. If a firm faces risk in the value of option positions, the firm must select appropriate option pricing models, quantify needed inputs, and consider various approaches to modifying the option position used. For example, the firm could use dynamic hedging or take offsetting option positions in exchange traded or OTC options. The appropriate transactions must be executed and the risk measurement and management process must begin again.

Risk governance is a part of the overall *corporate governance system* and refers to the overall process of developing and putting a risk management system into use. The system must specify between centralized and decentralized approaches, reporting methods, methodologies to be used, and infrastructure needs. High quality risk governance will be 1) transparent, 2) establish clear accountability, 3) cost efficient in the use of resources, 4) and effective in achieving desired outcomes.

Senior management is responsible for the overall system and must determine whether the system will be **decentralized** or **centralized**.

- A *decentralized* risk governance system places responsibility for execution within each unit of the organization. It has the benefit of putting risk management in the hands of those closest to each part of the organization.
- The *centralized* system [also called an **enterprise risk management (ERM)** system] places execution within one central unit of the organization. It provides a better view of how the risk of each unit affects the overall risk borne by the firm (i.e., individual risks are less than perfectly correlated, so the risk of the firm is less than the sum of the individual unit risks). For example, individual units might take offsetting positions in global equity markets, and the offsetting effects of the trades can only be seen from the perspective of upper management. In addition, a centralized system locates responsibility closer to senior management who bear ultimate responsibility. Management must consider each risk in isolation but also the overall impact on the firm. The centralized system will offer economies of scale.

LOS 34.b: Evaluate the strengths and weaknesses of a company's risk management process.

LOS 34.c: Describe the characteristics of an effective risk management system.

CFA® Program Curriculum, Volume 5, pages 197, 201

In either the decentralized or centralized approach, senior management must find a way to assess the overall impact of risk on the organization. Those who measure and report on risk levels must be independent of those who trade and take risk in the organization. The **back office**, which is responsible for processing transactions, record keeping, and compliance, must be independent from the **front office**, which generates transactions and sales in order to provide a check on the activities of the front office. The back office

must also interact with third parties, such as custodians and trading partners, to verify all transactions are accounted for and reported correctly.

An effective system will:

- Identify each risk factor to which the company has exposure.
- Quantify the factor in measurable terms.
- Include each risk in a single aggregate measure of firm-wide risk. VAR will be the most commonly used tool.
- Identify how each risk contributes to the overall risk of the firm. This is an advantage of VAR.
- Systematically report the risks and support an allocation of capital and risk to the various business units of the firm.
- Monitor compliance with the allocated limits of capital and risk.

Risk management will involve costs but is essential. Regardless of whether the approach is centralized or decentralized, the system must centralize the data collection and storage used in the process in order to be technologically efficient.

EVALUATING RISK

For the Exam: Be prepared for questions that test your knowledge of the steps that have been discussed. A typical question may include a long factual discussion of an organization and then require you to recognize what has been done correctly and what has not. Also be able to identify, given the facts, which specific risks are faced by the company.

LOS 34.d: Evaluate a company's or a portfolio's exposures to financial and nonfinancial risk factors.

CFA® Program Curriculum, Volume 5, page 201

A company faces both **financial** and **non-financial risks**. Financial risks arise from events external to the company and in the financial markets. Financial risks include:

- **Market risk** is related to changes in interest rates, exchange rates, equity prices, commodity prices, and so on. Each of these risks can be tied to changes in supply and demand in particular markets. Market risk is frequently the largest component of risk.

It may be appropriate to measure market risk in terms of changing market value. In the case of defined benefit pension plans and other entities with definable liabilities, an asset liability approach (ALM) to measuring surplus may be required.

- **Credit risk** is frequently the second largest financial risk. It is defined here as the risk of loss caused by a counterparty's or debtor's failure to make a promised payment. Traditionally, credit risk was seen as binary—a payment is made or not. The evolution of trading in credit derivatives has allowed for more refined measurement of credit risk and for the ability to hedge credit risk.

- **Liquidity risk** is the possibility of sustaining significant losses due to the inability to take or liquidate a position quickly at a fair price. It can be difficult to measure because liquidity can appear adequate until adverse events occur. A narrow **bid-ask spread** is usually taken as an indicator of good liquidity for traded securities but this spread normally applies only to small transactions. Another problem is that the valuation models used to value non-traded securities generally do not incorporate liquidity risk in estimating value. **Average** or **typical trading volume** may provide a better indication of liquidity. It is often assumed that derivatives can provide an alternative to transactions in the actual item, but in reality, derivative liquidity is generally linked to liquidity of the underlying item.

Non-financial risks are defined as all other risks and include:

- **Operational** or **operations risk** is a loss due to failure of the company's systems and procedures or from external events outside the company's control. Examples and solutions to operational risk include: computer failure which can be mitigated with backup systems and procedures, human failure which can be reduced by developing procedures to monitor actions, and terrorism or weather events for which insurance may be available.
- **Settlement risk** is present whenever funds are exchanged. One party could be making a payment while the other side of the exchange could be in the process of defaulting and fail to deliver on the transaction. This is also known as **Herstatt risk**¹. This level of risk varies. It is minimal for exchange trades when a clearinghouse assumes responsibility for the transaction. OTC transactions will have considerably more risk. On a swap where cash flows are exchanged, netting can be used to reduce the risk. Instead of each side making a payment and being at risk the other side will not pay, the smaller net difference in payments is computed and only that difference is sent. Many foreign exchange trades are now done through *continuously linked settlements (CLS)*, which provide for settlement within a defined time window to reduce settlement risk.
- **Model risk** is present for many derivatives and non-traded instruments. Models are only as good as their construction and inputs (e.g., the assumptions regarding the sensitivity of the firm's assets to changes in risk factors, the correlations of the risk factors, or the likelihood of an event).
- **Sovereign risk** is a form of credit risk (financial risk) but has other elements as well. The analyst must consider financial issues (the ability of the government to pay) in addition to non-financial issues (the willingness of a sovereign government to repay its obligations). It can be difficult to collect if a sovereign government does not want to pay.
- **Regulatory risk** arises when it is not clear how a transaction will be regulated or if the regulations can change. Even if a transaction is unregulated, the parties to the transaction may be regulated, making the transaction indirectly regulated.
- **Tax, Accounting, and Legal/Contract risk** are similar to regulatory risk in that they refer to situations where the rules are unclear or can change. Such situations can also

1. In June 1974, Herstatt bank had taken in Deutschemark currency swap receipts but had not made any of its U.S. dollar payments when German banking regulators closed it. See <http://riskinstitute.ch/134710.htm> for a discussion of foreign currency settlement risk and the failure of Bankhaus Herstatt.

lead to costly litigation. **Political risk** refers to a change in government which could then lead to any of these types of changes and risks.

Clearly derivatives are prime candidates for these risks. Many derivatives are new and subject to uncertain or changing rules. They can at times be politically unpopular.

Other risks include:

- **ESG (environmental, social, governance) risk** exists if company decisions result in environmental damage, human resource issues, or poor corporate governance policies and these decisions cause harm that results in a decline in the company's value.
- **Performance netting risk** can exist when there are multiple contracts and payments received on one contract are expected to cover payouts on another. For example, B may earn a fee from A and plan to use it to make a payment owed to C, but the payment received from A may be inadequate or even fail to occur with B still liable to make the payment to C. This risk could be reduced by netting; B would be removed from the exchange and A would pay C.
- **Settlement netting risk** is different. It refers specifically to the liquidator of a counterparty in default changing the terms of expected netting agreements, such that the non-defaulting party now has to make payments (a payment that was expected to have been netted and therefore reduced) to the defaulting party.

Measuring Risks

Risk measurement is focused primarily on measuring market and credit risk.

Traditionally, market risk has been measured with tools such as:

1. Standard deviation to measure price or surplus volatility.
2. Standard deviation of excess return. Excess return is the return minus the relevant benchmark return. The standard deviation of excess returns is also called **active risk** or **tracking risk**.

Tools exist to make simple, linear, first-order projections of the change in price for many securities: beta for stock, duration for bonds, and delta for options. Second-order techniques to measure change from straight line price projections exist for bonds (convexity) and options (gamma). Option price analysis can also incorporate the change in the option price for a change in time to expiration (theta) and the change in volatility (vega).



Professor's Note: Essentially, you are responsible for anything taught regarding the above items in other sections of the CFA material. It is difficult to aggregate the above tools into a single risk measure for a complex portfolio or organization. The focus of this reading is on VAR and other tools to compliment and support VAR.

VALUE AT RISK (VAR)

LOS 34.e: Calculate and interpret value at risk (VAR) and explain its role in measuring overall and individual position market risk.

CFA® Program Curriculum, Volume 5, page 213

VAR gained prominence in the 1990s as a single aggregate risk measure applicable to many situations. VAR states at some probability (often 1% or 5%) the expected loss during a specified time period. The loss can be stated as a percentage of value or as a nominal amount. VAR always has a dual interpretation.

Example: Interpreting VAR

A \$100 million portfolio has a 1.37% VAR at the 5% probability over one week. Calculate what could be lost and explain what the loss means.

Answer:

Over one week, the portfolio could lose 1.37% of \$100 million or \$1.37 million. There is a 5% chance that more than this will be lost and a 95% chance that less than this will be lost.

Analysis should consider some additional issues with VAR:

- The VAR time period should relate to the nature of the situation. A traditional stock and bond portfolio would likely focus on a longer monthly or quarterly VAR while a highly leveraged derivatives portfolio might focus on a shorter daily VAR.
- The percentage selected will affect the VAR. A 1% VAR would be expected to show greater risk than a 5% VAR.
- The left-tail should be examined. *Left-tail* refers to a traditional probability distribution graph of returns. The left side displays the low or negative returns, which is what VAR measures at some probability. But suppose the 5% VAR is losing \$1.37 million, what happens at 4%, 1%, and so on? In other words, how much worse can it get?

METHODS FOR COMPUTING VAR

LOS 34.f: Compare the analytical (variance–covariance), historical, and Monte Carlo methods for estimating VAR and discuss the advantages and disadvantages of each.

CFA® Program Curriculum, Volume 5, page 215

Three approaches are used in calculating VAR.

The Analytical VAR Method

The **analytical method** (or variance-covariance method) is based on the normal distribution and the concept of one-tailed confidence intervals.

Example: Analytical VAR

The expected annual return for a \$100,000,000 portfolio is 6.0% and the historical standard deviation is 12%. Calculate VAR at 5% significance.

Answer:

A CFA candidate would know that 5% in a single tail is associated with 1.645, or approximately 1.65, standard deviations from the mean expected return. Therefore, the 5% annual VAR is:

$$\begin{aligned}\text{VAR} &= [\hat{R}_p - (z)(\sigma)] V_p \\ &= [6.0\% - 1.65(12.0\%)](\$100,000,000) \\ &= -13.8\%(\$100,000,000) \\ &= -\$13,800,000\end{aligned}$$

where:

$\hat{R}_p$ = expected return on the portfolio

V_p = value of the portfolio

z = z -value corresponding with the desired level of significance

σ = standard deviation of returns

The interpretation is that there is 5% probability that the annual loss will exceed \$13.8 million and a 95% probability the annual loss will be less.

For the Exam: Be sure to know:

- 5% VAR is 1.65 standard deviations below the mean.
- 1% VAR is 2.33 standard deviations below the mean.
- VAR for periods less than a year are computed with return and standard deviations expressed for the desired period of time. For monthly VAR, divide the annual return by 12 and the standard deviation by the square root of 12. Then, compute monthly VAR. For weekly VAR, divide the annual return by 52 and the standard deviation by the square root of 52. Then, compute weekly VAR.
- For a very short period (1-day) VAR can be approximated by ignoring the return component (i.e., enter the return as zero). This will make the VAR estimate worse as no return is considered, but over one day the expected return should be small.

Example: Computing weekly VAR

For the previous example compute the weekly VAR at 1%.

Answer:

The number of standard deviations for a 1% VAR will be 2.33 below the mean return. The weekly return will be $6\% / 52 = 0.1154\%$. The weekly standard deviation will be $12\% / 52^{1/2} = 1.6641\%$

$$\text{VAR} = 0.1154\% - 2.33(1.6641\%) = -3.7620\%$$

Advantages of the analytical method include:

- Easy to calculate and easily understood as a single number.
- Allows modeling the correlations of risks.
- Can be applied to shorter or longer time periods as relevant.

Disadvantages of the analytical method include:

- Assumes normal distribution of returns.
 - ♦ Some securities have skewed returns. Long option positions have positive skew with frequent small losses (lose the premium paid) and occasional large gains if the option moves deep in-the-money. Short option positions will have the opposite payoff and negative skew.
 - ♦ Variance-covariance VAR has been modified to attempt to deal with skew and options in the **delta-normal method**. The adjustments are cumbersome and less than completely satisfying. A mathematical trick is used. The non-normal option price pattern is simulated to be normal by projecting the option price as the price of the underlying stock multiplied by the option's delta. The result will be a normal price distribution, but for larger changes in price it will not correctly reflect the true option price. Efforts to then model in a second order gamma (change in delta) effect become more cumbersome.

- Many assets exhibit leptokurtosis (fat tails). When a distribution has “fat tails,” VAR will tend to underestimate the loss and its associated probability as extreme returns occur more frequently than assumed by the normal distribution.
- The difficulty of estimating standard deviation in very large portfolios. Standard deviation is generally computed from asset correlations and covariance. The required number of covariances for each pair of assets increases geometrically with the number of assets.

The Historical VAR Method

The historical method for estimating VAR is sometimes referred to as the **historical simulation** method. One way to calculate the 5% daily VAR using the historical method is to accumulate a number of past daily returns, rank the returns from highest to lowest, and identify the lowest 5% of returns. The highest of these lowest 5% of returns is the 1-day, 5% VAR.

Example: Historical VAR

You have accumulated 100 daily returns for your \$100,000,000 portfolio. After ranking the returns from highest to lowest, you identify the lowest five returns:

–0.0019, –0.0025, –0.0034, –0.0096, –0.0101

Calculate daily VAR at 5% significance using the historical method.

Answer:

Because these are the lowest five returns, they represent the 5% lower tail of the “distribution” of 100 historical returns. The fifth lowest return (–0.0019) is the 5% daily VAR. We would say there is a 5% chance of a daily loss exceeding 0.19%, or \$190,000.

Advantages of the historical method include:

- Very easy to calculate and understand.
- Does not assume a returns distribution.
- Can be applied to different time periods according to industry custom.

The primary *disadvantage* of the historical method is the assumption that the pattern of historical returns will repeat in the future (i.e., it is indicative of future returns). This becomes particularly troublesome the more the manager trades. Also keep in mind that many securities (e.g., options, bonds) change characteristics with the passage of time.

The Monte Carlo VAR Method

The **Monte Carlo method** uses computer software to generate hundreds or thousands of possible outcomes from the distributions of inputs *specified by the user*. The user might specify normal distributions for some assets, skewed for others, leptokurtic for others,

and complex shifting correlations over time. The runs of possible outcomes can be ranked from highest to lowest (just like historical outcomes) to determine the result at any given probability. The data could be shown graphically to provide a visual display of all outcomes and frequency.

Example: Monte Carlo VAR

A Monte Carlo model has generated 100 runs of possible output over 1-week periods. The average return and standard deviation are 5.7% and 2.1% respectively. The worst six outcomes are +5%, +1.5%, +1.6%, +0.3%, +0.7% and +0.5%. The portfolio is known to include extensive option positions.

Calculate the 1-week VAR at 5% significance for a beginning portfolio value of GBP 100 million.

Answer:

Option positions make the use of standard deviation inappropriate for calculating VAR. Based on the Monte Carlo simulations, the 5th percentile worst result is the 5th worst return of +1.5% for a GBP 1,500,000 gain in portfolio value over one week. 5% of the time the gain would be worse.

It appears this is a very conservative portfolio because the VAR is a gain. Typically VAR is a loss but not in this case.

The primary *advantage* of the Monte Carlo method is also its primary disadvantage. It can incorporate any assumptions regarding return patterns, correlations, and other factors the analyst believes are relevant. For some portfolios it may be the only reasonable approach to use.

That leads to its downside: the output is only as good as the input assumptions. This complexity can lead to a false sense of overconfidence in the output among the less informed. It is data and computer intensive which can make it costly to use in complex situations (where it may also be the only reasonable method to use).

ADVANTAGES AND LIMITATIONS OF VAR

LOS 34.g: Discuss the advantages and limitations of VAR and its extensions, including cash flow at risk, earnings at risk, and tail value at risk.

CFA® Program Curriculum, Volume 5, page 229

VAR, whatever the method of computation, has several advantages over other risk measures:

- It has become the industry standard for risk measurement and is required by many regulators.
- It aggregates all risk into one single, easy to understand number.

- It can be used in capital allocation. For example, a firm willing to accept a maximum of \$1,000,000 VAR is essentially saying it is willing to lose \$1,000,000 of equity capital (at some probability level). Senior management could further allocate a maximum VAR to each business unit in the firm and evaluate each unit on the return generated for the VAR allowed. Generally, the total VAR by unit will be more than the \$1,000,000 firm-wide VAR. When the correlation between units is less than 1.0, the firm-wide VAR will be less than their simple summation. This is known as **risk budgeting**, how much risk can each unit take?

VAR also has clearly acknowledged limitations:

- Some of the methods (Monte Carlo) are difficult and expensive.
- The different computation methods can generate different estimates of VAR.
- It can generate a false sense of security. It is only as good as the inputs and estimation process. Even when done correctly it is probabilistic; things can always be worse.
- It is one-sided, focusing on the left tail in the return distribution, and ignores any upside potential.

VAR should not be used in isolation but in combination with other tools and actions:

- VAR projections should be continually **back-tested** to compare actual results across multiple time periods with projections. Does the pattern of results fit the probability and outcomes projected by VAR?
- **Incremental VAR (IVAR)** is the effect of an individual item on the overall risk of the portfolio. IVAR is calculated by measuring the difference between the portfolio VAR before and after an additional asset, asset class, or other aspect of the portfolio is changed.
- **Cash flow at risk (CFAR)** measures the risk of the company's cash flows. Some companies cannot be valued directly, which makes calculating VAR difficult or even meaningless. Even when VAR can be calculated, CFAR may offer additional information. CFAR is interpreted much the same as VAR, but substitutes cash flow for value. In other words, CFAR is the minimum cash flow loss at a given probability over a given time period.
- **Earnings at risk (EAR)** is analogous to CFAR only from an *accounting earnings* standpoint. Both CFAR and EAR are often used to add validity to VAR calculations.
- **Tail value at risk (TVAR)** is intended to give additional insight into what happens if VAR is exceeded. It is VAR plus the average of the outcomes in the tail. For example if the 5%, 1-day VAR is \$1 million and TVAR is \$2.7 million, then 5% of the time losses exceed \$1 million and the average lost is another \$1.7 million beyond \$1 million for a total average loss of \$2.7 million.
- **Credit VAR** projects risk due to credit events. It will be discussed shortly.
- **Stress testing** is a compliment to VAR.

STRESS TESTING

LOS 34.h: Compare alternative types of stress testing and discuss the advantages and disadvantages of each.

CFA® Program Curriculum, Volume 5, page 231

Stress testing is often employed as a complement to VAR. It may reveal outcomes not reflected in the typical VAR calculation. For example, the manager might use the historical standard deviation in estimating VAR, and if nothing unusual occurred during the measurement period, the estimated VAR will reflect only “normal” circumstances. Stress testing is just an extreme scenario.

Scenario Analysis

Scenario analysis is used to measure the effect on the portfolio of simultaneous movements in one or several factors. In a scenario analysis the user defines the events, such as interest rate movements, changes in currencies, changes in volatilities, changes in asset liquidity, and so on, and compares the value of the portfolio before and after the specified events.

Potential weaknesses in any scenario analysis include the inability to accurately measure by-products of major factor movements (i.e., the impact a major movement in one factor has on other factors) or include the effects of simultaneous movements in risk factors. Of course, user specification of the movements and their correlations is a potential weakness because it allows unintentional as well as intentional misspecification of the model.

There are various forms of scenario analysis. With stylized scenarios, the analyst changes one or more risk factors to measure the effect on the portfolio. Rather than having the manager select risk factors, some stylized scenarios are more like industry standards. For example, in *Framework for Voluntary Oversight*,² the Derivatives Policy Group (DPG) identifies nine specific risk factors to include in stress testing.

2. *Framework for Voluntary Oversight*, Derivatives Policy Group, March 1995.

For the Exam: The following lists risk factors that might be modeled in a scenario analysis.

1. Parallel yield curve shifts.
2. Changes in steepness of yield curves.
3. Parallel yield curve shifts combined with changes in steepness of yield curves.
4. Changes in yield volatilities.
5. Changes in the value of equity indices.
6. Changes in equity index volatilities.
7. Changes in the value of key currencies (relative to the U.S. dollar).
8. Changes in foreign exchange rate volatilities.
9. Changes in swap spreads in at least the G-7 countries plus Switzerland.

By providing guidelines, these stylized scenarios help managers avoid the “Oh no” syndrome, as in, “Oh, no! Why didn’t we think of that?”

Other forms of scenario analysis include **actual extreme events** and **hypothetical events**, which are quite similar. With the former, the analyst measures the impact of major past events, such as the market crash of 1987 or the 1990s technology bubble, on the portfolio value. Hypothetical events are extreme events that might occur but have not previously occurred. These tests are subject to the same weaknesses as other scenario analyses (e.g., incorrect assumptions and correlations, user bias).

Stressing Models

Stress testing and stressing models are just an extension of scenario analysis focusing on adverse outcomes. Stressing can be done as:

- **Factor push analysis** is a simple stress test where the analyst pushes factors to the most disadvantageous combination of possible circumstances and measures the resulting impact on the portfolio.
- **Maximum loss optimization** uses more sophisticated mathematical and computer modeling to find this worst combination of factors.
- **Worst-case scenario** is the worst case the analyst thinks is likely to occur.

For the Exam: Scenario analysis is discussed in multiple sections of the CFA material. Understand the concept, vocabulary, and be prepared to answer questions.

EVALUATING CREDIT RISK

LOS 34.i: Evaluate the credit risk of an investment position, including forward contract, swap, and option positions.

CFA® Program Curriculum, Volume 5, page 233

Credit risk exists when there is a possibility a counterparty to a transaction will not fulfill its responsibility. Credit risk is complicated to measure. Complicating the analysis is the fact that defaults are rare so there is little data available to assist in making estimates. Projecting credit losses is a function of:

1. The probability of a default event.
2. The amount of value lost if the default event occurs, which requires estimating the loss and any recovery after the initial loss.

Credit risk can be both immediate and potential. **Current credit risk** (also called **jump-to-default risk**) is the amount of a payment currently due. Because payments are only due on specific dates, current credit risk is zero on all other dates. **Potential credit risk** is associated with payments due in the future and exists even if there is no current credit risk. It will change over time. A firm can be currently solvent and able to make payment but that does not guarantee future payments will be made. Likewise, a firm could be in short-term financial difficulty but expected to recover if given time.

Credit risk can also be affected by **cross-default-provisions**. In most lending agreements, a debtor is considered in default of all obligations if it defaults on any one of its obligations. In addition to potential credit risk associated with their own receipts, therefore, creditors are exposed to potential credit risk from a debtor defaulting on an obligation to another creditor.

Credit VAR

Credit VAR (also called **credit at risk** or **default VAR**) is defined much like VAR as an expected loss (due to default) at a given probability during a given time period. However, it is more difficult to calculate and interpret than market VAR.

- It cannot be separated from VAR. If a security has little market value (for example, a bond with little value due to high interest rates) then there can be little credit VAR because there is little value to be lost if default occurs. While market VAR is called left-tail risk because it occurs when returns on the asset are low and market value is lost, credit VAR is right-tail risk as credit risk is greatest when returns and market value are highest.
- Even if the probability of default can be estimated, there is still the issue of estimating recovery rates.
- The pricing data of credit derivatives has provided additional insight into the market opinion of potential loss on securities. Option pricing models have also been applied to gain some insight. Like options, credit risk is one-sided, on a reasonable quality security upside is limited but default leads to substantial loss of value.
- Credit risk across multiple exposures is difficult to aggregate and would depend on the correlation of default between each pair of exposures.

Despite the difficulty of modeling and aggregating credit risk, at any one moment the potential credit risk of an investment is its current market value. That market value will be determined by 1) the remaining cash flows to be exchanged (and at risk) and 2) the degree to which market conditions have changed to create a gain or loss in value. The credit risk is one-sided, meaning the party with positive market value is at risk if the counterparty does not perform. The counterparty with negative market value has no potential credit risk. Under current conditions they are at a loss and would actually benefit if the transaction could somehow cease to exist. However, this does not mean potential credit risk will remain stable. As payments are made, the remaining cash flows at risk decrease which leads to a tendency for VAR to decrease. Additionally, market conditions can change, causing VAR to increase, decrease, or even reverse between the party with the gain and the party with the loss.

Forward Contracts

At the initiation of a standard forward contract, there is no exchange of cash and initial value is zero. As time passes, interest rates or prices have probably changed so that one of the counterparties will have a gain, putting that party at risk if the counterparty defaults. At any one point the potential credit risk is with the party who has a gain. At settlement of the contract the counterparty entitled to receive the payment faces *current credit risk*, as the payment is due immediately and the counterparty could default.

While at any future point in time the potential credit risk will be the current market value for the party with a gain, it can be anticipated that the potential credit risk will be highest in the middle to later part of the contract's life. All cash flow occurs at expiration so all cash flow remains at risk until expiration; the more time that passes from initiation of the contract, the greater the opportunity for conditions to change and create significant gain and credit risk for one counterparty.

Example: Credit risk in a forward contract

Suppose a forward contract that expires in one year is available on an asset that is currently worth \$100 and the risk-free rate is 4%; therefore, the forward price would be $\$100 \times 1.04 = \$104$. It is now nine months later, and the asset is worth \$101.50. **Determine** who bears the credit risk in the forward contract and **calculate** the amount of the credit risk.

Answer:

The holder of the long position in the contract is obligated to buy the asset for \$104 in one year. The value to the long is:

$$\$101.50 - \frac{\$104}{1.04^{3/12}} = -\$1.4852$$

Because the value is negative, this means the long position would owe the short position this amount if the contract was settled today. The value to the short position is positive, representing a claim on the asset in this amount from the long; thus, the short bears the *potential* credit risk, and because the contract is not settled for another three months, there is no *current* credit risk.

Example: Valuing the credit risk of a foreign exchange forward contract

As part of a foreign exchange hedging strategy, a U.S. portfolio manager has shorted a forward contract on euros denominated in U.S. dollars with a forward price of \$1.8095/€.³ With three months remaining on the contract, the spot rate is now \$1.8038/€, the U.S. interest rate is 5.5%, and the foreign interest rate is 5.0%. Determine the value and direction of any credit risk.

Answer:

To determine whether either party to a foreign currency forward contract is exposed to credit risk, we calculate the value of the contract to the long position. Because payoffs to forward contracts are symmetric, if the value of the contract is positive to the long, it must be negative to the short. The short position has an incentive to default, so the long faces the credit risk. Likewise, if the value to the long is negative, the short has value and faces the credit risk.

The value of a forward contract to the long position *per unit of notional principal* is the existing spot rate, discounted at the foreign interest rate (f), minus the forward rate, discounted at the domestic interest rate (d):

$$\text{value to long} = \frac{\text{spot exchange rate}}{(1+f)^t} - \frac{\text{forward exchange rate}}{(1+d)^t}$$



Professor's Note: We use direct exchange rates (i.e., domestic over foreign) from the perspective of the manager. The foreign interest rate is the interest rate associated with the foreign currency, which in this case is the euro.

The forward and spot rates in our example are \$1.8095/€ and \$1.8038/€, respectively. The domestic interest rate is 5.5%, and the foreign interest rate is 5%. Three months remain in the contract, so the present value of the contract to the *long* per unit of notional principal is as follows (remember, our manager is short the contract):

$$\begin{aligned} \text{value to long} &= \frac{\text{spot exchange rate}}{(1+f)^t} - \frac{\text{forward exchange rate}}{(1+d)^t} \\ &= \frac{\$1.8038/\text{€}}{1.05^{0.25}} - \frac{\$1.8095/\text{€}}{1.055^{0.25}} = -\$0.003509/\text{€} \end{aligned}$$

3. Since this forward contract is written on euros, shorting the contract means agreeing to sell (deliver) euros at the forward price. Going long the contract would mean agreeing to purchase euros at the forward price. *Denominated in U.S. dollars* indicates that the forward price for euros is stated in dollars.

The value to the long is negative, so the short (our portfolio manager) has positive value under the forward contract and is thus exposed to the credit risk. Had the notional principal in our example been €1,000,000, the total amount of credit risk faced by our portfolio manager would have been $€1,000,000 \times (\$0.003509/€) = \$3,509$.



Professor's Note: Because we work with dollars per euro in the example (i.e., per unit of notional principal), we could have simply denoted the spot and forward prices as \$1.8038 and \$1.8095, respectively. Likewise, the value of the contract to the long could be stated as −\$0.003509.

Swaps

A swap should be thought of as a series of forward contracts. Following this analysis, the swap will have actual credit risk on each payment exchange date as well as potential credit risk throughout its life. So unlike the forward there is actual credit risk on multiple dates and on each of these dates, as cash flows are exchanged, subsequent cash flows to be exchanged in the future decrease. At any future point, potential credit risk is the value of the swap for the counterparty with a gain.

Unlike a forward, the credit risk of most swaps (such as *interest rate* and *equity swaps*) is expected to be highest somewhere around the middle of their life. Assuming the swap is correctly priced, the initial value and credit risk are zero. Then as some time passes and conditions change, one or both parties will have credit risk. If both parties are required to make payments both will be at risk the other counterparty is unable to pay. In the more common netting of payment situation, the credit risk will be one-sided and to the party with the gain. As the swap nears its maturity and the number of remaining settlement payments decreases, the credit risk also decreases.

The exception to this is a *currency swap*. Because payments are in different currencies, netting of settlement payments is inappropriate and both parties can be simultaneously exposed to current credit risk on settlement dates. Also, due to the exchange of principals at inception and the return of principals on the maturity date, the credit risk of a currency swap is highest between the middle and final maturity of the agreement. The notional principal is very large in relation to the periodic cash flows and remains at risk until the last exchange.

Options

With an option, unlike a forward or swap contract, only the long position (the buyer) faces credit risk. The buyer decides whether to exercise the option and will only do so when there is positive value. Only the buyer is at risk the seller will be unable to perform.

For both American and European options, the buyer will have potential credit risk equal to the current market value of the option. Theoretically the American-style option value

can be somewhat higher because it is never worth less than a European-style option. Neither style can have actual credit risk until it is exercised. With the American, that actual risk could occur prior to expiration if the owner chooses to exercise early (a rare event). The European-style option can only have actual credit risk on the expiration date.

Liquidity and Non-financial Risks

Liquidity is not considered in measuring VAR. Implicit in VAR is the assumption that positions can be sold at their trading or estimated market value. Thus, VAR can give an inaccurate estimate of the true potential for loss. Estimating liquidity is difficult. For example, due to a statistical anomaly and in spite of large bid-ask spreads, some infrequently traded securities have low historical volatility. Even if historical volatility is accurate, the inability to quickly adjust a position can lead to increased losses not caught in the VAR measure. The manager should take this into account and consider how large their position is in relation to past and likely future trading volume.

Non-financial risks are difficult to measure. Many are outlier events for which the insurance industry may offer insurance and have a data base from which estimates of loss, recovery, and probability could be made.

MANAGING MARKET RISK

LOS 34.j: Demonstrate the use of risk budgeting, position limits, and other methods for managing market risk.

CFA® Program Curriculum, Volume 5, page 242

Risk budgeting is the process of determining which risks are acceptable and how total enterprise risk is allocated across business units or portfolio managers. Through an enterprise risk management (ERM) system, upper management allocates different amounts of capital across portfolio managers. In this fashion, the amount of capital (and the associated VAR) allocated to portfolio managers (e.g., foreign currency, domestic and international bonds, equities) is based upon management's prior determination of the desired exposure to each sector.

An ERM system affords the ability to continuously monitor the risk budget so that any deviations are immediately reported to upper management. Another benefit of a risk budgeting system is the ability to compare manager performance in relationship to the amount of capital and risk allocated (i.e., measure risk-adjusted performance with **return on VAR**).

Example: Return on VAR

Assume Manager A and B work for the same firm. Manager A has been allocated \$100 million of capital and a weekly VAR of \$5 million. Manager B has been allocated \$500 million and a weekly VAR of \$10 million. Over a given period, A earns a profit of \$1 million, and B earns a profit of \$3 million. Their combined capital and VAR are \$600 million and \$13.7 million

Compare their results using *return on capital* and *return on VAR*. Discuss their combined capital and VAR.

Answer:

	<i>A</i>	<i>B</i>
Capital (funds that can be invested)	\$100,000,000	\$500,000,000
VAR	\$5,000,000	\$10,000,000
Profit	\$1,000,000	\$3,000,000
Return on capital	1%	0.6%
Return on VAR	20%	30%

By comparing the managers on return on capital, it appears that A outperformed B. When we measure return on VAR, however, Manager B outperformed Manager A on a risk-adjusted basis.

The capital position of each manager is a simple summation of capital positions. VAR is a more complex aggregation and will be less than a simple addition when correlation is less than 1.0

In addition to VAR, methods for managing market risk include:

- **Position limits** that place a nominal dollar cap on a given position.
- **Liquidity limits** are related to position limits. In an effort to minimize liquidity risk, risk managers may set nominal position limits as some portion of typical trading volumes.
- A **performance stopout** sets an absolute dollar limit for losses to the position over a certain period. If the stopout level is hit, the position must be closed to limit further loss.
- In addition to a VAR allocation, the portfolio manager may be subject to individual **risk factor limits**. As the name implies, the manager must limit exposure to individual risk factors as prescribed by upper management.

Other measures include **scenario analysis limits**, which require the manager to structure the portfolio so as to limit the impact of given scenarios, and **leverage limits**, which limit the amount of leverage the manager can employ.

MANAGING CREDIT RISK

LOS 34.k: Demonstrate the use of exposure limits, marking to market, collateral, netting arrangements, credit standards, and credit derivatives to manage credit risk.

CFA® Program Curriculum, Volume 5, page 245

Credit VAR based on standard deviation is inherently difficult to apply to one-sided credit risk. Credit change for most traditional securities is on the downside with limited upside. While credit VAR may be considered, other methods to limit credit risk are extensively employed:

- **Limiting exposure** is a rational first line of defense against credit risk. It means limiting the amount of loans to any individual debtor or the amount of derivative transactions with any individual counterparty.
- **Marking to market** is employed with many derivative contracts in which the value to one party will be positive while the value to the other will be negative. The party whose value is negative pays this amount to the other party, and the contract is repriced.

Example: Marking to market of a forward contract

Assume there is a 1-year forward contract at \$106 with the risk-free rate of 5%, and it is three months into the life of the contract. If the current spot price is \$104, **determine** the cash flows, assuming the parties have agreed to mark to market every three months.

Answer:

The market value to the long is as follows:

$$\$104 - \frac{\$106}{1.05^{9/12}} = \$1.8087$$

Therefore, the short owes the long this amount. The contract will be repriced at $\$104(1.05)^{9/12} = \$107.876$, and the two parties will mark to market again at the 6-month point.

- **Collateral** is often required in transactions that generate credit risk. For example, consider the typical home purchase where the homeowner must provide equity of 5% to 20% of the total value of the home. In business transactions, collateral can be business assets or liquid marketable securities.

In derivatives markets, both parties are often required to post *margin*, and if the contract is marked to market, either side may be required to post additional margin (collateral).

- **Payment netting** is frequently employed in derivatives contracts that can generate credit exposure to both sides. When each side has credit risk, we value and *net* the two to determine which side has the greater obligation. If the contract has a mark-to-market clause, one side pays the other, and the contract is repriced at the new forward rate.
- **Closeout netting** is employed in *bankruptcy* proceedings. In this case, all the transactions between the bankrupt company and a single counterparty are netted to determine the overall exposure. When this is done, the bankrupt firm cannot claim assets equaling payments it is due while at the same time defaulting on its obligations.
- It is always wise to impose **minimum credit standards** on a debtor. The quality of the debtor—the debtor's creditworthiness—is sometimes hard to evaluate with any confidence. For example, commercial banks, the largest derivatives dealers, make loans to many types of debtors at the same time they are in countless derivatives contracts. Any time the dealer, or any counterparty for that matter, is simultaneously in numerous contracts, creditworthiness is difficult to ascertain.

A lower credit quality entity can meet minimum credit standards by creating subsidiaries with the special purpose of entering into derivatives (or other) contracts. These **special purpose vehicles** (SPVs) and **enhanced derivatives products companies** (EDPCs) are completely separate from the parent companies and established with sufficient capital to ensure high credit ratings. By restructuring them this way, problems with the parent, such as credit downgrades, are not reflected in the ratings of the SPV or EDPC.

- Risk can be transferred to somebody else through **credit derivatives**, such as credit default swaps, credit forwards, credit spread options, and total return swaps.
 - ♦ In a **credit default swap**, the protection buyer (i.e., the asset holder) makes regular payments to the dealer and receives a payment when a specified credit event occurs.
 - ♦ A **credit spread forward** is also based upon a credit spread, but as with other forward contracts, there will almost always be a payment by one of the parties. That is, there will be a payment unless the reference spread equals the spread specified in the contract.
 - ♦ The holder of a **credit spread option** receives a payment when the rate on an asset exceeds a reference yield (such as LIBOR) by more than the specified spread. The payment partially compensates for the decline in the value of the asset. Note that because this is an option, it has value, and a payment is made only if it is in-the-money.
 - ♦ In a **total return swap**, the asset owner agrees to accept a variable return from a dealer in exchange for the total return on an asset. When the asset is subject to capital gains and losses, the dealer accepts both the credit and interest rate risk. That is, if the asset increases in value, the owner passes the capital gain along to the dealer in the form of a cash payment. Likewise, if the asset decreases in value, the dealer makes a payment to the asset owner.

For the Exam: Credit derivatives and credit events are discussed in more detail in Study Session 10.

MEASURING RISK-ADJUSTED PERFORMANCE

LOS 34.1: Discuss the Sharpe ratio, risk-adjusted return on capital, return over maximum drawdown, and the Sortino ratio as measures of risk-adjusted performance.

CFA® Program Curriculum, Volume 5, page 248

The **Sharpe ratio** measures excess return (over the risk-free rate) per unit of risk, measured as standard deviation. The principal drawback to applying the Sharpe ratio as a measure of risk-adjusted return is the assumption of normality in the excess return distribution. This is particularly troublesome when the portfolio contains options and other instruments with non-symmetric payoffs. The formula for the Sharpe ratio is:

$$S_P = \frac{\bar{R}_P - \bar{R}_F}{\sigma_P}$$

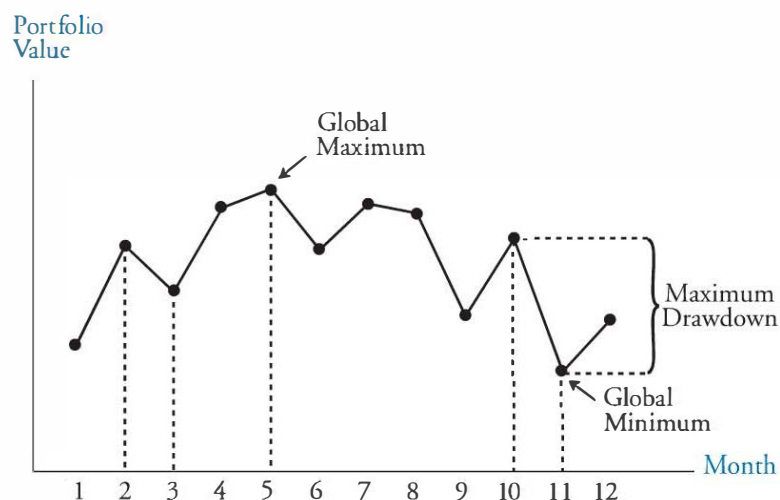
Risk-adjusted return on invested capital (RAROC). RAROC is the ratio of the portfolio's expected return to some measure of risk, such as VAR (see our earlier discussion of return on VAR). Management can then compare the manager's RAROC to his historical or expected RAROC or to a benchmark RAROC.

Return over maximum drawdown (RoMAD). *Drawdown* is the difference between a portfolio's highest and lowest sub-period values over a given measurement period. The *maximum drawdown* is the largest drawdown over the total period. To calculate RoMAD, the analyst divides the average portfolio return in the period by the maximum drawdown:

$$\text{RoMAD} = \frac{\bar{R}_P}{\text{maximum drawdown}}$$

To demonstrate RoMAD, consider Figure 1, which shows representative month-end portfolio values. Drawdown is experienced any time the portfolio moves from a peak to a subsequent trough. For example, the first drawdown for the year occurred when the portfolio moved from a local maximum at the end of month 2 to a *local* minimum at the end of month 3. These are only locals because they are not the maximum or minimum value of the portfolio for the year. For example, at the end of month 5, the portfolio hit its global maximum for the year, while at the end of month 11 it hit its global minimum.

Figure 1: Monthly Portfolio Values and Maximum Drawdown



Because RoMAD can be interpreted as indicating the risk undertaken in earning the return (i.e., return per unit of risk), the higher the RoMAD, the better. We'll assume the maximum drawdown was 2.5%. We will further assume the portfolio's average monthly return was 1.1%.

This yields a RoMAD of 0.44:

$$\text{RoMAD} = \frac{\text{average monthly return}}{\text{maximum drawdown}} = \frac{1.1}{2.5} = 0.44$$

RoMAD is similar in concept to the Sharpe and information ratios, as all three measure average return as a percentage of the risk faced in earning it. Maximum drawdown is considered more intuitive than standard deviation as a measure of risk, however, because it deals with more “concrete” numbers. (Standard deviation, although widely accepted, is a statistical property and is difficult to think of as a number, per se.) Note that maximum drawdown measures the maximum *range* of the changes in portfolio value, which investors can easily visualize. Like standard deviation, however, using RoMAD also makes an implicit assumption that historical return patterns will continue.

Like the other risk-adjusted return measures, the Sortino ratio is the ratio of excess return to risk. Excess return for the Sortino ratio (the numerator) is calculated as the portfolio return less the *minimum acceptable portfolio return* (MAR). The denominator of the ratio is the standard deviation of returns calculated using only returns below the MAR. The motivation behind the downside measure of volatility utilized in the Sortino ratio is the sense that very good performance (high returns) can unfairly inflate the volatility measure (the standard deviation used as the risk measure).

$$\text{Sortino} = \frac{\bar{R}_p - \text{MAR}}{\text{downside deviation}}$$

SETTING CAPITAL REQUIREMENTS

LOS 34.m: Demonstrate the use of VAR and stress testing in setting capital requirements.

CFA® Program Curriculum, Volume 5, page 250

Because unusual events are not typically captured with VAR, stress testing (scenario analysis) is used to estimate their effect on the value of a firm or portfolio. In addition, stress testing helps determine whether the firm has sufficient capital to withstand unusual events. In measuring the capital adequacy of a firm, for example, analysts and regulators look for sufficient capital to withstand a major loss, which could result from the occurrence of one or more unusual events.

To determine the allocation of capital across business units or portfolio managers, upper management must determine the allocation in a way that maximizes potential returns without placing the viability of the firm in jeopardy. In other words, they must measure both the expected returns and potential losses of individual units or managers and ensure that the amount of capital at risk never exceeds total firm capital.

To this point we have looked at various methods for measuring risk-adjusted returns, but we have not discussed the capital allocation process itself. Measuring and allocating capital can be done with:

- **Nominal position limits**, also called **notional position limits** or **monetary position limits**, are specified in terms of the amount of money that will be allocated across portfolio managers based upon upper management's desire for return and exposure to risk. Simply put, management allocates capital where they feel it will produce the highest risk-adjusted returns. They allocate heavily where they feel managers will perform well with minimum risk exposure. If management feels the portfolio is subject to significant losses, they limit the amount of capital.

Problems associated with nominal position limits stem from the ability of the individual portfolio manager to exceed the limit by combining assets (usually derivatives) to replicate the payoffs of other assets and from management's inability to capture the effects of correlation among the nominal positions. Therefore, although it is an easily understood capital allocation technique, it suffers as a risk management technique.

- **VAR-based position limits** are sometimes used in lieu of or to supplement nominal position limits because VAR is an assessment of capital at risk. To achieve the desired overall risk exposure (measured by VAR), capital is allocated across business units or portfolio managers according to VAR. Remember that VAR is the maximum expected loss in percent multiplied by the value of the portfolio. If upper management feels an individual position is subject to potentially significant percentage losses, they limit the capital allocated. In doing so, they limit the VAR.

The benefit is a clear overall VAR picture, the sum of the individual unit VARs. The drawback is that the measure does not consider the correlation of the different positions. This can lead to overestimating firm VAR and misallocating capital.

- A **maximum loss limit** is simply the maximum allowable loss. Regardless of the individual VAR, each unit or manager is given a very strict maximum loss limit. The sum of the individual maximum loss limits, then, is the theoretical maximum the firm will have to endure. The benefit to setting maximum loss limits is the ability to allocate capital such that the total maximum loss never exceeds the firm's capital. The drawback is the possibility of all units simultaneously exceeding their limits due to unforeseen market conditions (unusual events).
- **Internal capital requirements and regulatory capital requirements.** Some capital requirements are set by regulation (e.g., banks). Using VAR-based measures, for example, bank regulators set capital requirements such that the probability of insolvency is acceptable. Frequently, management will set capital requirements internally. Again, using VAR, management allocates capital such that the probability of insolvency (i.e., the probability that losses exceed the firm's capital) is acceptable.

Behavioral conflicts. The ERM system must recognize the potential for incentive conflicts between management, which allocates the risk, and those who make the investment decisions, the portfolio managers. For example, once the portfolio is recognized to be headed for a loss for the period, the portfolio manager, whose salary and bonus are typically tied to positive performance, has little incentive to minimize risk. In fact, the manager might well have an incentive to increase risk in hopes of generating a profit. Recognizing this potential, the system and upper management must take steps to avoid it through monitoring or even in the structuring of performance incentives.



Professor's Note: Management can totally eliminate the possibility of insolvency by investing only in risk-free assets. Because companies, including portfolio managers, are not in business to earn risk-free returns, they must accept some level of risk. In doing so, the probability of insolvency will be positive. Managing the probability of insolvency means keeping it within acceptable levels of perhaps 1% to 2%.

KEY CONCEPTS

LOS 34.a

Risk management is a continual process of:

- Identifying and measuring specific risk exposures.
- Setting specific risk tolerance levels.
- Reporting risk exposures (deemed appropriate) to stakeholders.
- Monitoring the process and taking any necessary corrective actions.

Risk governance should originate from senior management, which determine the structure of the system [i.e., whether centralized (a single group) or decentralized (risk management at the business unit level)].

A decentralized risk governance system has the benefit of putting risk management in the hands of the individuals closest to everyday operations. A centralized system (also called an enterprise risk management system or ERM) provides a better view of how the risks of the business units are correlated.

LOS 34.b, c

In evaluating a firm's ERM system, the analyst should ask whether:

- Senior management consistently allocates capital on a risk-adjusted basis.
- The ERM system properly identifies and defines all relevant internal and external risk factors.
- The ERM system utilizes an appropriate model for quantifying the potential impacts of the risk factors.
- Risks are properly managed.
- There is a committee in place to oversee the entire system to enable timely feedback and reactions to problems.
- The ERM system has built in checks and balances.

A risk management problem can be an event associated with a macro or micro factor, or even the ERM system itself. When a problem occurs:

- Identify the problem and assess the damage.
- Determine whether the problem is due to a temporary aberration or a long-term change in capital market structure or pricing fundamentals.
- If the problem is temporary, the best action may be none at all.
- If the problem is deemed a long-run change in fundamentals or comes from within the ERM system itself, corrective action is justified.
- If the problem stems from a risk factor that was previously modeled incorrectly, revisit the risk model.
- If the problem stems from a risk factor that was not originally identified and priced, management must determine whether to manage the risk or hedge it.
- A problem can also arise from reliance on an incorrectly specified risk pricing model (i.e., risk could be modeled using an incorrect metric).

LOS 34.d

As part of an ERM system, an analyst needs to recognize the financial and non-financial factors that have the potential to significantly affect the company's earnings or even its long-run viability.

Some of the specific risks that must be monitored include:

- Market risk (financial risk). Factors that directly affect firm or portfolio values (e.g., interest rates, exchange rates, equity prices, commodity prices).
- Liquidity risk (financial risk). The possibility of sustaining significant losses due to the inability to take or liquidate a position quickly at a fair price.
- Settlement risk (non-financial risk). The possibility that one side of a position is paying while the other is defaulting.
- Credit risk (financial risk). Default of a counterparty. This risk can be mitigated through the use of derivative products, such as credit default options.
- Operations risk (non-financial risk). The potential for failures in the firm's operating systems, including its ERM system, due to personal, technological, mechanical, or other problems.
- Model risk (non-financial risk). Models are only as good as their construction and inputs.
- Sovereign risk (financial and non-financial risk components). The willingness and ability of a foreign government to repay its obligations.
- Regulatory risk (non-financial). Different securities in the portfolio can fall under different regulatory bodies.
- Some other risks (all non-financial) include political risk, tax risk, accounting risk, and legal risk, which relate directly or indirectly to changes in the political climate.

Rather than as defined in portfolio theory (systematic risk), market risk in this context refers to the response in the value of an asset (security, portfolio, or company) to changes in interest rates, exchange rates, equity prices, and/or commodity prices.

When measured relative to a benchmark, the volatility (standard deviation) of the asset's excess returns is called active risk, tracking risk, tracking error volatility, or tracking error.

The manager's excess return over the benchmark, called active return, is typically compared to the historical volatility of excess returns, measured by active risk. The ratio of the active return to the active risk is known as the information ratio (IR):

$$IR_P = \frac{\text{active return}}{\text{active risk}} = \frac{R_P - R_B}{\sigma_{(R_P - R_B)}}$$

Some forms of nonfinancial risk, such as an operational risk like a power outage, can be anticipated and steps can be taken to avoid or compensate for them. Other types of operational risk, such as extreme weather in an agricultural region, can have dramatic consequences, but the possibility of the event is difficult to assess as is the extent of any related loss. Most nonfinancial risks are difficult to measure; therefore, managers buy insurance, which protects against these losses.

LOS 34.e

VAR is an estimate of the minimum expected loss (alternatively, the maximum loss):

- Over a set time period.
- At a desired level of significance (alternatively, at a desired level of confidence).

For example, a 5% VAR of \$1,000 over the next week means that, given the standard deviation and distribution of returns for the asset, management can say there is a 5% probability that the asset will lose a minimum of (at least) \$1,000 over the coming week. Stated differently, management is 95% confident the loss will be no greater than \$1,000.

VAR considers only the downside or lower tail of the distribution of returns. Unlike the typical z -score, the level of significance for VAR is the probability in the lower tail only (i.e., a 5% VAR means there is 5% in the lower tail).

LOS 34.f

The analytical method (also known as the variance-covariance method or delta normal method) for estimating VAR requires the assumption of a normal distribution. This is because the method utilizes the expected return and standard deviation of returns.

$$\text{VAR} = [\hat{R}_p - (z)(\sigma)] V_p$$

where:

$\hat{R}_p$ = expected return on the portfolio

V_p = value of the portfolio

z = z -value corresponding with the desired level of significance

σ = standard deviation of returns

Advantages of the analytical method include:

- Easy to calculate and easily understood.
- Allows modeling the correlations of risks.
- Can be applied to different time periods according to industry custom.

Disadvantages of the analytical method include:

- The need to assume a normal distribution.
- The difficulty in estimating the correlations between individual assets in very large portfolios.

The historical method for estimating VAR is sometimes referred to as the historical simulation method. The easiest way to calculate the 5% daily VAR using the historical method is to accumulate a number of past daily returns, rank the returns from highest to lowest, and identify the lowest 5% of returns. The highest of these lowest 5% of returns is the 1-day, 5% VAR.

Advantages of the historical method include:

- Easy to calculate and easily understood.
- No need to assume a returns distribution.
- Can be applied to different time periods according to industry custom.

The primary disadvantage of the historical method is the assumption that the pattern of historical returns will repeat in the future (i.e., is indicative of future returns).

The Monte Carlo method refers to computer software that generates hundreds, thousands, or more possible outcomes from the distributions of inputs specified by the user. After the output is generated it can be ranked from best to worst, just as in the historical method, to determine VAR at any desired probability.

The primary advantage of the Monte Carlo method is the ability to incorporate any returns distribution or asset correlation. This is also its primary disadvantage, however. The analyst must make thousands of assumptions about the returns distributions for all inputs as well as their correlations.

LOS 34.g

One primary *advantage* of VAR is the ability to compare the operating performance of different assets with different risk characteristics. A *disadvantage* of all methods for calculating VAR is that they suffer from the constant need to estimate inputs and make assumptions, and thus the problem becomes more and more daunting as the number of assets in the portfolio gets larger.

Cash flow at risk (CFAR) measures the risk of the company's cash flows. CFAR is interpreted much the same as VAR, only substituting cash flow for value.

Earnings at risk (EAR) is analogous to CFAR only from an *accounting earnings* standpoint. Both CFAR and EAR are often used to add validity to VAR calculations.

Tail value at risk (TVAR) is VAR plus the expected value in the tail of the distribution, which could be estimated by averaging the possible losses in the tail.

Extensions of VAR: VAR can also be used to measure credit at risk, and efforts have been made to estimate a variation of VAR for assets with non-normal distributions.

LOS 34.h

Stress testing, which is typically employed as a complement to VAR, measures the impacts of unusual events that might not be reflected in the typical VAR calculation. Stress testing can take two forms: scenario analysis and stressing models.

Scenario analysis is used to measure the effect on the portfolio of simultaneous movements in several factors or to measure the effects of unusually large movements in individual factors.

Potential weaknesses in any scenario analysis include the inability to accurately measure byproducts of major factor movements (i.e., the impact a major movement in one factor has on other factors) or include the effects of simultaneous adverse movements in risk factors.

Stressing models are extensions to the scenario analysis models and include factor push models, maximum loss optimization, and worst-case scenarios.

In factor push analysis, the analyst deliberately pushes a factor or factors to the extreme and measures the impact on the portfolio. Maximum loss optimization involves identifying risk factors that have the greatest potential for impacting the value of the portfolio and moving to protect against those factors. Worst-case scenario is exactly that the analyst simultaneously pushes all risk factors to their worst cases to measure the absolute worst case for the portfolio.

Because stressing models are just another version of scenario analysis, they suffer from the same potential problems; specifically, incorrect inputs and assumptions as well as the possibility of user bias.

LOS 34.i

Credit risk is the possibility of default by the counterparty to a financial transaction. The monetary exposure to credit risk is a function of the probability of a default event and the amount of money lost if the default event occurs.

At the settlement date for a forward contract, one or both parties will have to pay the other. The value of the forward contract (the associated credit risk) is the present value of any net payoff.

A swap should be thought of as a series of forward contracts, so the credit risk associated with a swap is *potential* until each settlement date. Likewise, the value of a swap is the present value of future settlement payments.

Unlike forward and swap contracts, the credit risk to an option is only borne by the long position. The credit risk to a *European* option, even if it is in-the-money, can only be potential until the date it matures. The credit risk of an American option will be at least as great as a similar European option.

LOS 34.j

Risk budgeting is the process of determining which risks are acceptable and how total enterprise risk is allocated across business units or portfolio managers. In addition to VAR, methods for managing market risk include:

- A position limit places a nominal dollar cap on a given position. Position limits are generally used by upper management to help maintain the desired level of firm wide diversification.
- Liquidity limits are related to position limits. In an effort to minimize liquidity risk, risk managers will set dollar position limits according to the frequency of trading volumes.
- A performance stopout goes beyond the VAR measure by setting an absolute dollar limit for losses to the position over a certain period.
- In addition to a VAR allocation, the portfolio manager may be subject to individual risk factor limits. As the name implies, the manager must limit exposure to individual risk factors as prescribed by upper management.

LOS 34.k

Due to the lack of historical data, measures such as VAR (which assumes a normal distribution) are very difficult, if not inappropriate, to use in managing credit risk. Several non-VAR measures have been developed to help control credit risk.

- Limiting exposure means limiting the amount of loans to any individual debtor or the amount of derivative transactions with any individual counterparty.
- Marking to market is employed with many derivative contracts.
- Collateral is often required in transactions that generate credit risk.
- Payment netting is frequently employed in derivatives contracts that can generate credit exposure to both sides. When each side has credit risk, we value and net the two to determine which side has the greater obligation.
- It is always wise to impose minimum credit standards on a debtor.
- Risk can be transferred to someone else through credit derivatives such as credit default swaps, credit forwards, credit spread options, and total return swaps.

LOS 34.l

The Sharpe ratio measures excess return (over the risk-free rate) per unit of risk, measured as standard deviation. The principal drawback to applying the Sharpe ratio as a measure of risk-adjusted return is the assumption of normality in the excess return distribution. This is particularly troublesome when the portfolio contains options and other instruments with non-symmetric payoffs.

$$S_p = \frac{\bar{R}_p - \bar{R}_F}{\sigma_p}$$

Risk-adjusted return on invested capital (RAROC). RAROC is the ratio of the portfolio's expected return to some measure of risk, such as VAR. Management can then compare the manager's RAROC to his historical or expected RAROC or to a benchmark RAROC.

Return over maximum drawdown (RoMAD). Drawdown is the difference between a portfolio's highest and lowest sub-period values over a given measurement period. The maximum drawdown is the largest drawdown over the total period.

$$\text{RoMAD} = \frac{\bar{R}_p}{\text{maximum drawdown}}$$

The Sortino ratio is the ratio of excess return to risk. Excess return for the Sortino ratio (the numerator) is calculated as the portfolio return less the minimum acceptable portfolio return (MAR). The denominator of the ratio is the standard deviation of returns calculated using only returns below the MAR.

$$\text{Sortino} = \frac{\bar{R}_p - \text{MAR}}{\text{downside deviation}}$$

LOS 34.m

Because unusual events are not typically captured with VAR, stress testing (scenario analysis) is used to estimate their effect on the value of a firm or portfolio. In addition, stress testing helps determine whether the firm has sufficient capital to withstand unusual events.

To determine the allocation of capital across business units or portfolio managers, upper management must determine the allocation in a way that maximizes potential returns without placing the viability of the firm in jeopardy. The capital allocation process involves setting:

- Nominal position limits.
- VAR-based position limits.
- Maximum loss limits.
- Internal and regulatory capital requirements.
- Behavioral conflicts.

CONCEPT CHECKERS

1. As risk manager for ABC Enterprises, J.Q. Smith is assessing the firm's various risk exposures to include in a regular semiannual report to upper management. ABC is a medium-size import/export firm located in Charleston, South Carolina. Its primary sources for imports, which it sells in the United States, are located in China and Mexico. It has customers throughout the world, but more than half of its exports go to the Eurozone.⁴ ABC customarily borrows to cover funds tied up in exports. Discuss risk exposures Smith should report.

2. In her first semiannual review of the firm's ERM system, B. Jones, the new risk manager, comes across the following two statements in the risk management policies and procedures manual:
 - The performance of each of the firm's portfolio managers will be assessed annually, and managers will be ranked from highest to lowest total return. Managers who have added the most value to their portfolios will receive increased capital allocations for the following year.
 - It is the responsibility of each portfolio manager to monitor and maintain the risk of the portfolio within normal, acceptable levels as described in the IPS.

State and explain whether the actions described in each of the statements is appropriate for an effective ERM system. In addition to your discussion on these two statements, **state** at least two other characteristics of a good ERM system.

3. A portfolio contains two assets, A and B. The expected returns are 9% and 13%, respectively, and their standard deviations are 18% and 21%, respectively. The correlation between the returns on A and B is estimated at 0.50. **Calculate** the 5% (analytical) VAR of a \$100,000 portfolio invested 75% in A and 25% in B. List a total of two advantages and/or disadvantages of analytical VAR.

⁴ Eurozone is the name given to the countries that have adopted the euro as currency. They include Austria, Belgium, Cyprus, Estonia, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Malta, the Netherlands, Portugal, Slovakia, Slovenia, and Spain.

4. Below are 40 monthly returns (in percent) for LMN Portfolio, ranked from highest to lowest. Calculate the 5% historical VAR for the \$1,500,000 portfolio. List a total of two advantages and/or disadvantages of historical VAR.

6.147	2.377	1.594	0.993	−0.672	−1.523
5.875	2.232	1.320	0.989	−0.749	−1.726
3.660	2.064	1.189	0.962	−0.851	−2.024
3.432	2.059	1.148	0.901	−1.112	−2.250
3.376	1.839	1.128	0.353	−1.182	−3.359
2.510	1.652	1.054	−0.231	−1.313	
2.388	1.609	0.996	−0.550	−1.367	

5. List and describe four types of financial risk, and offer mitigating strategies.
6. List and describe five types of nonfinancial risk, and offer mitigating strategies.
7. Because VAR has certain limitations, managers will often back test their VAR models (i.e., check the accuracy of their VAR predictions after the fact). In addition, there are measures that can be used as supplements to the regular VAR measure (i.e., supplement the information provided by VAR). List and describe two measures that can be used as supplements to VAR.

8. List and discuss three methods for managing credit risk.
9. One of your portfolio managers, Mort Van Sleet, has recently complained that by measuring risk-adjusted returns using the Sharpe ratio, he is placed at an unfair disadvantage. He has stated flatly that the standard deviation of his portfolio returns is artificially inflated. **Explain** how this can be true, and **offer** and **explain** a potential solution to the problem.
10. While reading and entering return data into a performance evaluation model, the programmer transposed the number 0.10 to 0.01. As a result, the average return and maximum drawdown for the period were calculated incorrectly for that manager. The mistake was discovered only immediately before paying out bonuses and allocating capital for the coming year. **Discuss** the failure in the ERM system and possible remedies.
11. A German portfolio manager entered a 3-month forward contract with a U.S. bank to deliver \$10,000,000 for euros at a forward rate of €0.8135/\$. One month into the contract, the spot rate is €0.8170/\$, the euro rate is 3.5%, and the U.S. rate is 4.0%. **Determine** the value and direction of any credit risk.

ANSWERS – CONCEPT CHECKERS

1. In determining the risks to report, the credit manager should consider market, credit, liquidity, operational, model, settlement, regulatory, legal, tax, accounting, sovereign, and political risks.
 - Market risk pertains to interest rates, exchange rates, and stock and commodity prices. The manager should report ABC's exposures to interest rates (because it borrows to cover short-term cash needs) and exchange rates (because of exposures to international foreign currencies).
 - The manager should report exposure to credit risk because the firm's customers no doubt buy on credit.
 - Liquidity risk, which pertains to the ability to buy/sell securities quickly at a fair price, is probably not a concern for ABC, unless it utilizes forward contracts on foreign currencies.
 - The firm will face operational risk to the extent that its business activities are sensitive to operational difficulties (e.g., interruptions in the transportation of products).
 - The firm faces model risk if it values its exposures to foreign currencies and attempts to take offsetting positions. Some exposures may be very difficult to determine accurately because they deal with customers all over the globe, and small currencies may be difficult to model.
 - Settlement risk applies to transactions that include payments due to and receipts due from counterparties. There is not enough information to make a determination on whether the firm faces settlement risk.
 - They are exposed to regulatory risk in that foreign countries can change regulations on imports and exports.
 - Legal risk pertains to the enforcement of contracts. Different international laws can make enforcement of contracts somewhat challenging if a foreign counterparty disputes the terms of a contract.
 - Any business is subject to the possibility of changing tax laws. Global trade exacerbates this problem, also.
 - The company may be exposed to accounting risk if it deals with less-developed nations that follow different and possibly changing accounting rules. Changing accounting rules can affect the profitability (business risk) of those customers.
 - Sovereign risk generally pertains to governments, so unless the company deals with a foreign government, sovereign risk is probably not a concern. If it does sell to foreign governments, payment of bills is always subject to the government's willingness and ability to pay.
 - Political risks pertain to changing political climate. Even if the firm faces little domestic political risk, it is definitely exposed to the risks associated with the political climate of its trading partners.

2. "The performance of each of the firm's portfolio managers will be assessed annually, and managers will be ranked from highest to lowest total return. Managers who have added the most value to their portfolios will receive increased capital allocations for the following year."

Inappropriate. Senior management should allocate capital (consistently) on a risk-adjusted basis.

"It is the responsibility of each portfolio manager to monitor and maintain the risk of the portfolio within normal, acceptable levels as described in the IPS."

Inappropriate. A functional ERM system should provide for performance monitoring by a risk management committee that reports directly to upper management.

Other characteristics of an ERM system:

- The ERM system properly identifies and defines all relevant internal and external risk factors.
- The ERM system utilizes an appropriate model for quantifying the potential impacts of the risk factors.
 - Does the model include correlations of the risk factors to enable management to evaluate the firm's overall risk position from a portfolio perspective?
 - Does the model allow for potential combinations of risk factors simultaneously impacting the firm?
 - Does the model allow for changing factor sensitivities?
- Risks are properly managed.
 - Has management identified risks for which it has sufficient experience, information, and tools to provide effective management?
 - Has management identified risks it is uncomfortable with and that should be reduced or eliminated (hedged)?
 - There is a committee in place to oversee the entire system to enable timely feedback and reactions to problems.
- The ERM system has built-in checks and balances.
 - Does it provide for continual monitoring and feedback on the risk factors?
 - Does it provide for continual monitoring and feedback on the risk management system itself?
 - Does it evaluate the ability of the risk model to accurately estimate and quantify the risks?
 - Does it have a mechanism for incorporating newly identified risks?

3. To calculate VAR, we need the portfolio expected return and standard deviation:

$$\hat{R}_P = 0.75(0.09) + 0.25(0.13) = 0.0675 + 0.0325 = 0.10$$

$$\sigma_P^2 = (0.75)^2 (0.18)^2 + (0.25)^2 (0.21)^2 + 2(0.75)(0.25)(0.18)(0.21)(0.50) = 0.02807$$

$$\sigma_P = \sqrt{\sigma_P^2} = 0.1675$$

then:

$$\text{VAR} = V_P [\hat{R}_P - Z(\sigma_P)], \text{ where } Z = 1.65$$

$$\text{VAR} = \$100,000 [0.10 - 1.65(0.1675)] = -\$17,637$$

The manager is 95% confident the maximum loss over the coming year will not be greater than \$17,637. Alternatively, the manager can say there is a 5% probability of a loss greater than \$17,637 (i.e., that \$17,637 is the minimum loss).

Advantages of the analytical method include:

- It is easy to calculate and easily understood.
- It allows modeling the correlations of risks.
- It can be applied to different time periods according to industry custom.

Disadvantages of the analytical method include:

- The need to assume a normal distribution.
- The difficulty in estimating the correlations of very large portfolios.
- No indication of the size of potential losses in the tail.

4.

6.147	2.377	1.594	0.993	-0.672	-1.523
5.875	2.232	1.320	0.989	-0.749	-1.726
3.660	2.064	1.189	0.962	-0.851	-2.024
3.432	2.059	1.148	0.901	-1.112	-2.250
3.376	1.839	1.128	0.353	-1.182	-3.359
2.510	1.652	1.054	-0.231	-1.313	
2.388	1.609	0.996	-0.550	-1.367	

Using the historical method, 5% VAR is determined using the highest return of the lowest 5% of historical returns. With 40 returns, the bottom 5% would be the $0.05(40) = 2$ lowest returns (highlighted in the table above). Because -2.25% is the higher of the two, the 5% historical VAR is $(-2.25\%)(1,500,000) = -\$33,750$.

The manager could say she is 95% confident that the portfolio will not experience a loss greater than \$33,750. Alternatively, the manager could say with 5% significance that the minimum loss will be \$33,750 (5% probability of a loss greater than \$33,750).

Advantages of the historical method include:

- It is easy to calculate and easily understood.
- There is no need to assume a returns distribution.
- It can be applied to different time periods according to industry custom.

The primary disadvantage of the historical method is the assumption that the pattern of historical returns will repeat in the future (i.e., is indicative of future returns).

5.

Financial risks:

- Market risk (financial risk). Factors that directly affect firm or portfolio values (e.g., interest rates, exchange rates, equity prices, commodity prices, etc.).
- Liquidity risk (financial risk). The possibility of sustaining significant losses due to the inability to take or liquidate a position quickly at a fair price.
- Credit risk (financial risk). Default of a counterparty. This risk can be mitigated through the use of derivative products, such as credit default options.
- Sovereign risk (financial and non-financial risk components). The willingness and ability of a foreign government to repay its obligations.

Mitigating strategies for financial risks will typically include the use of financial and credit derivatives including options, futures and/or forward contracts, futures options, and swaps.

6.

Nonfinancial risks:

- Operations risk (non-financial risk). The potential for failures in the firm's operating systems, including its ERM system, due to personal, technological, mechanical, or other problems.
- Model risk (non-financial risk). Models are only as good as their construction and inputs (e.g., the assumptions regarding the sensitivity of the firm's assets to changes in risk factors, the correlations of the risk factors, or the likelihood of an event).
- Sovereign risk (financial and non-financial risk components). The willingness and ability of a foreign government to repay its obligations.

- Regulatory risk (non-financial). Different securities in the portfolio can fall under different regulatory bodies. Also, synthetic positions (combinations of two or more securities to create the effect of a totally different asset) can be quite confusing.
- Some other risks (all non-financial) include political risk, settlement risk, tax risk, and legal risk, which relate directly or indirectly to changes in the political climate.

Due to the difficulties in predicting the occurrence and size of a loss due to nonfinancial risks, managers will often simply purchase insurance protection.

- Supplements (additions) to VAR used to provide more confidence in the accuracy of the VAR calculation include:
 - Incremental VAR (IVAR). IVAR is the effect of an individual asset on the overall risk of the portfolio. IVAR is calculated by measuring the difference between the portfolio VAR with and without the asset.
 - Cash flow at risk (CFAR). Some companies cannot be valued directly, which makes calculating VAR difficult or even meaningless. Instead of using VAR, CFAR measures the risk of the company's cash flows.
 - Earnings at risk (EAR) is analogous to CFAR only from an *accounting earnings* standpoint.
 - Tail value at risk (TVAR). TVAR is VAR plus the expected value in the tail of the distribution, which could be estimated by averaging the possible losses in the tail.
- Methods used to limit credit risk include:
 - Limiting exposure, which means limiting the amount of loans to any individual debtor or the amount of derivative transactions with any individual counterparty.
 - Marking to market is employed with many derivative contracts. Contracts are settled on a regular basis, which means that profits and losses are settled.
 - Collateral is often required in transactions that generate credit risk. In derivatives markets, both parties are often required to post *margin*, and if the contract is marked to market, either side may be required to post additional margin (collateral).
 - Payment netting is frequently employed in derivatives contracts that can generate credit exposure to either side. The party with the net payment due is the only party at risk. Netting is also employed in *bankruptcy* proceedings. In this case, all the transactions between the bankrupt company and a single counterparty are netted to determine the overall exposure.
- In calculating the traditional standard deviation, all returns for the measurement period are used (e.g., all the positive and negative alphas). This is like looking at the entire normal distribution, with the benchmark return as the center of the distribution. Negative alphas would fall to the left of the benchmark return, and positive alphas would fall to the right.

The manager is arguing that only negative alphas are relevant for measuring risk. This would be analogous to using only the left half of that normal distribution. Using the Sortino ratio compensates for this by only using returns below a designated level.

Excess return for the Sortino ratio (the numerator) is calculated as the portfolio return less the minimum acceptable portfolio return (MAR). The denominator of the ratio is the standard deviation of returns calculated using only returns below the MAR. The motivation behind the downside measure of volatility utilized in the Sortino ratio is the sense that very good performance (high returns) can unfairly inflate the volatility measure (the standard deviation used as the risk measure).

10. This “failure” in the ERM system is part of the operational risk associated with implementing the performance evaluation model (risk-adjusted performance compared to some benchmark), not a problem with the model itself. The first step in reacting to any risk management problem is determining the value of any damage and whether the problem is transient or permanent. In this case, the occurrence in question is not permanent in nature, and any monetary damage can be quickly and easily rectified. The likelihood of a similar occurrence in the future is high, however, so management should be sure a process is in place to help reduce the likelihood of future incorrect data entries.
11. The German manager (short position) has contracted with a U.S. bank to sell dollars at €0.8135, and the dollar has strengthened to €0.8170. The manager would be better off in the spot market than under the contract, so the bank faces the credit risk (the manager could default). From the perspective of the U.S. bank (the long position), the amount of the credit risk is:

$$V_{\text{bank (long)}} = \frac{\text{€}8,170,000}{(1.04)^{2/12}} - \frac{\text{€}8,135,000}{(1.035)^{2/12}} = \text{€}28,278$$

(The positive sign indicates the bank faces the credit risk that the German manager might default.)

We discount each cash flow from the perspective of who would receive it or would effectively receive it. The German manager will receive €8,135,000 under the contract, so we discount that amount at his domestic rate (the Euro rate) of 3.5%. The €8,170,000 is the amount the manager would receive in the spot market, so he is giving up that amount under the contract (effectively paying it to the bank). We therefore discount the €8,170,000 at the bank’s domestic rate (the U.S. rate) of 4%.

CURRENCY RISK MANAGEMENT

Study Session 14

EXAM FOCUS

This topic review discusses several techniques relating to currency hedging that have already been covered in other sections. It also covers new ground. The new ground starts with the minimum variance hedge ratio. Up until now, currency hedging has meant a 1-to-1 hedge ratio. If an investor has direct exposure to 1 million yen, sell 1 million yen forward. But what if there is a link between local market return, which is the return on a foreign denominated asset before it is converted back to the investor's currency (here called the return on the asset), and the local currency return, which is the change in the value of the currency? The minimum variance hedge ratio could be more or less than 1.0.

The use of currency options instead of futures and forwards is discussed, including the difference between protective puts and dynamic hedging. There is additional terminology and discussion of practical issues in hedging. Given the importance of international investing, know this section well.

HEDGING THE PRINCIPAL

LOS 35.a: Explain and demonstrate the use of foreign exchange futures to hedge the currency exposure associated with the principal value of a foreign investment.

CFA® Program Curriculum, Volume 5, page 270

In addition to the risk associated with the uncertain future value of the investment, foreign investing also exposes the investor to translation risk—the risk associated with exchanging the foreign currency back into the investor's domestic currency.

We will utilize the following example to demonstrate translation risk.

Example: Translation risk

Assume a U.S. investor makes a 90-day euro-denominated investment valued at €1,000,000. The spot exchange rate is \$1.2888/€, so the U.S. investor must invest $\$1.2888/\text{€} \times \text{€}1,000,000 = \$1.2888$ million. In 90 days, the spot rate is \$1.2760/€, and the investment is valued at €1,050,000. When the investment is liquidated and translated back into U.S. dollars, the investor receives $\text{€}1,050,000 \times \$1.2760/\text{€} = \$1,339,800$.

As seen in the following calculations, the return on the investment in the local currency (euros) is 5%, but the return in dollars is only 3.96%. Thus, the strengthening dollar reduced the (unhedged) return on the investment by 1.04%:

$V_{L,0}$ = value of the foreign asset at time 0 in the local currency

$V_{D,0}$ = value of the foreign asset at time 0 in the domestic currency

$V_{L,t}$ = value of the foreign asset at time t in the local currency

$V_{D,t}$ = value of the foreign asset at time t in the domestic currency

S_0 = spot exchange rate at time 0

S_t = spot exchange rate at time t

R_L = return on the asset in the local currency

$R_{D,u}$ = unhedged return on the asset in the domestic currency

$$R_L = \frac{V_{L,t} - V_{L,0}}{V_{L,0}} = \frac{1,050,000 - 1,000,000}{1,000,000} = 0.05 = 5.0\%$$

$$R_{D,u} = \frac{V_{D,t} - V_{D,0}}{V_{D,0}} = \frac{S_t V_{L,t} - S_0 V_{L,0}}{S_0 V_{L,0}} = \frac{1,339,800 - 1,288,800}{1,288,800} = 0.03957 = 3.957\%$$

$$\text{translation loss} = R_L - R_{D,u} = 5.00\% - 3.957\% = 1.043\%$$

We'll now assume the investor has utilized foreign exchange futures to hedge the translation risk. Because the investor wasn't sure of the future value of the investment, she decided to **hedge the principal** (i.e., the original €1,000,000 invested) by selling €1,000,000 in euro futures at \$1.2891/€.

At the time the investment is liquidated and the hedge is lifted, the spot exchange rate is \$1.2760/€, and the futures exchange rate is \$1.2763/€ (i.e., the dollar has strengthened). From our previous calculations, we know the unhedged return on the investment is 3.96%. Now, because the investor is effectively in two separate contracts (the investment in the foreign asset and the investment in the currency futures), we must calculate the return on the futures contract to determine the investor's overall (portfolio) return:

$$\begin{aligned} R_{\text{Fut}} &= €1,000,000 \times (-F_T + F_0) \\ &= €1,000,000 \times (-1.2763 + 1.2891) = \$12,800 \end{aligned}$$



Professor's Note: There is a negative sign in front of the equation because she sold futures.

where:

R_{Fut} = return on the futures contract

F_0 = futures exchange rate (dollars per euro) at time 0

F_t = futures exchange rate (dollars per euro) at time t

Comparing the dollar gain on the futures contract to the original investment, we see the futures generated an additional 0.993%:

$$\frac{F_T V_0 - F_0 V_0}{S_0 V_0} = \frac{\$12,800}{\$1,288,800} = 0.00993 = 0.993\%$$

The total return on the portfolio, which includes the asset and the futures contract, is:

R_P = unhedged return on the asset in the domestic currency + % change in futures price

R_P in dollars:

$$\begin{aligned}
 R_P &= \left(\frac{S_t V_{L,t} - S_0 V_{L,0}}{S_0 V_{L,0}} \right) + \left[- \left(\frac{F_t V_{L,0} - F_0 V_{L,0}}{S_0 V_{L,0}} \right) \right] \\
 &= \frac{1,339,800 - 1,288,800}{1,288,800} - \frac{\$1,276,300 - 1,289,100}{1,288,800} \\
 &= 0.03957 + 0.00993 = 0.0495 = 4.95\%
 \end{aligned}$$

For the Exam: The LOS asks you to explain and demonstrate, so you should be prepared to perform the calculations on the exam. For simplicity, I strongly recommend that you try no shortcuts. That is, calculate the unhedged return on the asset, calculate the return on the futures contract, and then add them to arrive at the total return. The question could, of course, ask you to “demonstrate the strategy the manager can use to hedge the currency risk and show the return without and with the hedge in place.” Remember to hedge the principal (i.e., the original investment) only.

Notice in our example that even though the investor hedged the principal, the portfolio return is still not the total 5% earned by the asset in the local currency. This is because she hedged only the principal and incurred a translation loss on the 5% *increase* in the value of the foreign asset. Had she hedged the entire €1,050,000, the dollar return on the futures contract would have been:

$$\begin{aligned}
 R_{\text{Fut}} &= €1,050,000 \times (-F_T + F_0) \\
 &= €1,050,000 \times (-1.2763 + 1.2891) = \$13,440
 \end{aligned}$$

Her total (portfolio) return would have been:

$$R_P = \frac{\$51,000 + \$13,440}{\$1,288,800} = 0.05 = 5\%$$

The difference between the total return when hedging the principal versus hedging the total value is $\$13,440 - \$12,800 = \$640$, which is 0.05% of the original investment ($\$640 / \$1,288,800 = 0.0005 = 0.05\%$). This is the translation loss on the €50,000 gain on the investment.

The dollar appreciated 0.993% against the euro over the period:

$$R_C = \frac{S_t - S_0}{S_0} = \frac{1.2760 - 1.2888}{1.2888} = -0.00993 = -0.993\%$$

where:

R_C = currency return (i.e., percentage change in the spot rate)

S_0 = spot exchange rate at time 0

S_t = spot exchange rate at time t

This means the investor lost 0.993% on the 5% gain or $(0.05)(0.00993) = 0.000497 \approx 0.05\%$. (Note: The difference is caused by rounding in the calculation of exchange rates.)

MINIMUM VARIANCE HEDGE

LOS 35.b: Justify the use of a minimum-variance hedge when local currency returns and exchange rate movements are correlated and interpret the components of the minimum-variance hedge ratio in terms of translation risk and economic risk.

CFA® Program Curriculum, Volume 5, page 273

In the example in LOS 35.a, we assumed the investor hedged only the principal and was unhedged against translation risk associated with the *return* on the asset. Also, we assumed a given return on the asset and equal percentage changes in the spot and futures exchange rates. In other words, we assumed away any risk associated with translating the principal (i.e., basis risk) as well as the uncertainty in the return on the asset. Obviously, letting these two factors vary would lead to a range of possible domestic returns (i.e., *variance* in the expected domestic return).

Also, an important factor was overlooked in that example. Specifically, we ignored the possibility that changes in exchange rates are often related to (correlated with) returns on assets. For example, an exporter's sales will increase (decrease) when the local currency depreciates (appreciates) and its products become cheaper (more expensive) to international buyers. This *covariance* between asset returns and exchange rate movements adds to the uncertainty associated with possible domestic returns and, thus, increases the variability of the expected return.

To minimize the variability in the expected return, the global investor can determine the **minimum-variance hedge ratio**, h . We determine h by regressing the domestic, unhedged return on the asset (or portfolio) on the currency futures return. The minimum variance hedge ratio is the resulting slope coefficient.

Translation Risk and Economic Risk

The preceding discussion points out two distinct risks associated with global investing—translation risk and economic risk. *Translation risk* is the risk associated with translating the value of the asset back into the domestic currency. *Economic risk* is the risk associated with the relationship between exchange rate changes and changes in asset values in the foreign market (i.e., correlation between changes in currency and asset values).

To show the relationship between the minimum-variance hedge ratio and these two risks, we start with the regression of the unhedged domestic return on the futures return to determine the optimal hedge ratio, h :

$$R_{D,u} = \alpha + h (R_{Fut})$$

where:

$R_{D,u}$ = unhedged domestic return

R_{Fut} = futures return (i.e., the percentage change in the futures price)

h = optimal hedge ratio

In any simple linear regression, the slope coefficient is equal to the covariance of the independent and dependent variables divided by the variance of the independent variable. Therefore, we can state h as:

$$h = \frac{\text{Cov}(R_{D,u}, R_{Fut})}{\sigma_{R_{Fut}}^2}$$

Algebraic manipulation accompanied by assumptions about the spot rate, futures rate, and the basis breaks the optimal hedge ratio, h , into its two components:

$$h = \frac{\text{Cov}(R_{D,u}, R_{Fut})}{\sigma_{R_{Fut}}^2} = h_T + h_E = 1 + \frac{\text{Cov}(R_L, R_C)}{\sigma_{R_C}^2} \Rightarrow h_T = 1 \text{ and } h_E = \frac{\text{Cov}(R_L, R_C)}{\sigma_{R_C}^2}$$

where:

h_T = portion of the hedge ratio that compensates for translation risk

h_E = portion of the hedge ratio that compensates for economic risk

R_L = asset return in the local currency

R_C = currency return (i.e., percentage change in the spot rate)

$\sigma_{R_C}^2$ = variance of the currency return

For the Exam: The derivation of this relationship is beyond the scope of the curriculum. Only the final result (the descriptions of h_T and h_E) are important for the exam (i.e., the optimal hedge ratio, h , is the sum of h_T and h_E).

Translation risk. The first term in the equation ($h_T = 1$) refers to the optimal hedge ratio to compensate for translation risk, and it says the ratio should be 1.0. This means 100% of the principal should be hedged (i.e., *hedging the principal* as demonstrated earlier). When we hedge the principal using futures, the hedge ratio does not change ($h_T = 1$).

Economic risk. The second term in the equation, $h_E = \frac{\text{Cov}(R_L, R_C)}{\sigma_{R_C}^2}$, is the portion of

the optimal hedge ratio that compensates for economic risk. We see it depends upon the covariance of local asset returns and currency movements.

BASIS RISK

LOS 35.c: Evaluate the effect of basis risk on the quality of a currency hedge.

CFA® Program Curriculum, Volume 5, page 277

Basis is the difference between the spot and futures exchange rates at a point in time. The magnitude of the basis depends upon the spot rate and the interest rate differential between the two economies. *Interest rate parity* describes the relationship between spot and futures exchange rates and local interest rates:

$$\frac{F_{D/L}}{S_{D/L}} = \frac{1 + i_D}{1 + i_L}$$

where:

$F_{D/L}$ = current futures rate expressed as domestic per local

$S_{D/L}$ = current spot rate expressed as domestic per local

i_D = domestic interest rate corresponding to the maturity of the futures

i_L = local interest rate corresponding to the maturity of the futures

It's clear that if the ratio of the interest rates should change, the ratio of the futures rate to the spot rate changes accordingly. If, for example, the domestic interest rate increases relative to the local rate, the futures rate also increases (i.e., the domestic currency depreciates relative to the local currency).

In our example in LOS 35.a, the percentage changes in the spot and futures exchange rates were deliberately constructed to be the same (i.e., interest rates maintained the same relationship, so the *basis* didn't change). Had the basis changed, the value of the hedge would have increased or decreased. That is, the gain on the futures contract could have been more or less than the translation loss on the principal. The investor must be aware of basis risk any time a futures hedge will be lifted **prior to the futures maturity date**. To avoid basis risk, the investor would have to match the maturity of the futures contract with the intended holding period.

To see the effects of changes in the basis (i.e., basis risk), recall that in our previous example, the percentage change in the spot rate was exactly the same as the percentage change in the futures rate. That is, the *basis* remained the same over the period:

$$S_0 = \$1.2888 / \text{€}; S_t = \$1.2760 / \text{€}$$

$$F_0 = \$1.2891 / \text{€}; F_t = \$1.2763 / \text{€}$$

$$\% \Delta \text{ spot} = \frac{S_t - S_0}{S_0} = \frac{\$1.2760 / \text{€} - \$1.2888 / \text{€}}{\$1.2888 / \text{€}} = -0.00993$$

$$\% \Delta \text{ futures} = \frac{F_t - F_0}{F_0} = \frac{\$1.2763 / \text{€} - \$1.2891 / \text{€}}{\$1.2891 / \text{€}} = -0.00993$$

We'll now assume the basis is not constant. We will assume that the percentage change in the futures exchange rate is *less than* the percentage change in the spot exchange rate.

(Note that the unhedged return is assumed to be the same as in the original example. Also, the opposite would of course happen if the change in the futures exchange rate is *greater than* the change in the spot exchange rate.)

Assume that in 90 days the futures exchange rate is \$1.2780/€ instead of \$1.2763/€:

R_P in dollars:

R_P = unhedged return in domestic currency + futures return

$$\begin{aligned}
 R_P &= \left(\frac{S_t V_{L,t} - S_0 V_{L,0}}{S_0 V_{L,0}} \right) + \left[- \left(\frac{F_t V_{L,0} - F_0 V_{L,0}}{S_0 V_{L,0}} \right) \right] \\
 &= \left(\frac{\$1,339,800 - \$1,288,800}{\$1,288,800} \right) - \left(\frac{\$1,278,000 - \$1,289,100}{\$1,288,800} \right) \\
 &= 0.03957 + 0.00861 = 0.0482 = 4.82\%
 \end{aligned}$$

Notice first that the return in the futures contract has fallen to 0.861%. Then, because the basis moved against the investor, the total return on the investment has fallen from 4.95% to 4.82%.

CONTRACT TERMS

LOS 35.d: Discuss the choice of contract maturity in constructing a currency hedge, including the advantages and disadvantages of different maturities.

CFA® Program Curriculum, Volume 5, page 279

The first concern associated with the length of the contract is **basis risk**. The only way to avoid basis risk is to enter a contract (e.g., futures, swap, forward) with a maturity *equal* to the desired holding period. Only then does the investor lock in a rate of exchange for a long currency position (i.e., eliminate basis risk).



Professor's Note: In the following discussions, we assume hedging with futures.

When the futures contract is *longer* (i.e., has a longer maturity) than the desired holding period, the investor must reverse at the end of the holding period at the existing futures price. The futures price at that time is dependent upon the relationship of the interest rates in the two countries. Because that relationship may have changed after the implementation of the hedge, the basis may have also changed as we demonstrated in an example. Thus, if the investor selects a long-term futures contract (i.e., longer than the desired holding period), he faces basis risk.

If the futures contract is *shorter* than the desired holding period, the investor must close (i.e., reverse out of) the first contract and then enter another. Because they are two distinctly different contracts, the investor faces a risk very similar to that faced by the

investor who selects the long-term futures contract. That is, the first futures contract will converge to the spot rate at its maturity. The investor must reverse out of that contract and select another contract, whose price will depend upon the existing relationship of the interest rates in the two countries. At the inception of the original contract, therefore, the investor is unsure of the futures price he will get with the second contract. Of course, if after the first contract matures no contract exists with a maturity equal to the remaining holding period, the investor must decide whether to enter another short-term contract or a long-term contract.

Another concern is **trading costs**, which are incurred at inception and closing as well as any time the manager wishes to adjust the hedge according to changes in the value of the currency position. The more frequently the manager adjusts the hedge, the greater the commission costs generated, but the better the manager matches the futures position to the currency position. For example, trading futures daily would provide the manager the ability to continually adjust the hedge to the current value of the currency position but would generate significant trading costs. Not adjusting at all over the holding period generates no trading costs, but the value of the futures contract could deviate significantly from the value of the currency position.

A short-term contract strategy, by design, allows the manager to adjust the hedge each time the contracts mature. Therefore, short-term contracts generate higher commission costs than longer-term contracts because they increase the number of transactions necessary to adjust the hedge.

HEDGING MULTIPLE CURRENCIES

LOS 35.e: Explain the issues that arise when hedging multiple currencies.

CFA® Program Curriculum, Volume 5, page 280

Currency futures and forward contracts are not always actively traded, so hedging the movements in some of the currencies in a multi-currency portfolio may be difficult and inefficient. In these cases, it may be desirable to use a cross hedge (i.e., hedge using an actively traded futures contract on a correlated currency). Of course, whether any or all of the currencies represented in the portfolio are hedged depends upon the manager's expectations.

To determine the optimal hedge ratio for a multi-currency portfolio, the manager can perform sort of a returns-based style analysis. Rather than attempt to determine an optimal hedge ratio for each individual currency, the manager can regress the portfolio's historic domestic currency returns on the futures returns for a few major, actively traded currencies.

For example, a European investor (domestic currency is the euro) might regress his portfolio's historic domestic euro returns on the futures returns for the pound, yen, and U.S. dollar:

$$R_D = \alpha + h_1 F_1 + h_2 F_2 + h_3 F_3 + e$$

where:

h_i = optimal hedge ratio for currency i

F_i = return on currency future i



Professor's Note: Futures returns may not be readily available. In that case, because changes in spot rates are the major driver of changes in futures prices, currency (spot) returns can be used as proxies in the regression.

CURRENCY OPTIONS

LOS 35.f: Discuss the use of options rather than futures/forwards to manage currency risk.

CFA® Program Curriculum, Volume 5, page 281

The primary benefit to using currency options rather than futures to protect against translation losses is the relative nature of their payoffs. The payoff to a futures contract is *symmetric*. That is, the investor must reverse out of the contract whether the currency appreciates or depreciates (i.e., the investor is protected against depreciation in the local currency but loses any appreciation in the local currency).

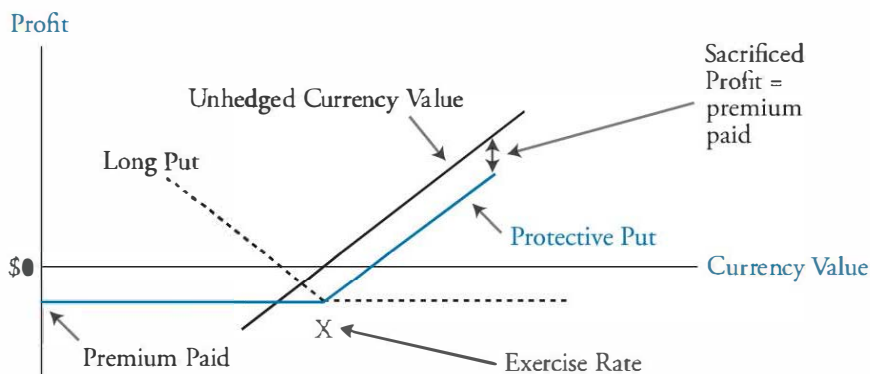
A put option, on the other hand, is used like *insurance* because it gives the holder the right to sell the currency at a specified price over a specified time period. If the local currency depreciates in value, the gain on the put offsets the loss. If the local currency appreciates, however, the investor allows the option to expire, trades in the spot market, and realizes the gain. This ability to gain on the upside while protecting against the downside comes at a cost, however. To enter the put contract, the investor must pay a premium, which is a sunk cost. That is, the premium is paid regardless of whether the option is exercised.

The size of the premium depends upon the exercise price. To protect against *any* depreciation in the local currency, for example, the investor buys at-the-money puts in an amount equal to the principal (hedges the principal). Increasing (decreasing) the exercise price will increase (decrease) the premium. Figure 1 shows the traditional graph of the protective put profit *at expiration*. You will notice that the investor gives up profit equal to the premium paid.



Professor's Note: If the put is in-the-money and the hedge is lifted prior to the put's maturity, the forfeited profit will be an amount somewhat less than the premium paid, as the option will retain its time value.

Figure 1: Profit on a Currency Protective Put



CURRENCY DELTA HEDGING

LOS 35.g: Evaluate the effectiveness of a standard dynamic delta hedge strategy when hedging a foreign currency position.

CFA® Program Curriculum, Volume 5, page 284

Professor's Note: Delta hedging is a dynamic strategy meaning that it must be continually rebalanced to accomplish the intended objective. The intent is quite different from a protective put (PP) and the PP does not require rebalancing. A PP buys and holds puts equal to the currency to be insured. A hedge ratio of 1.0. You have downside protection but retain upside if the currency appreciates.



With delta hedging, you are taking on sufficient options that instantaneous changes in value of the currency are offset by instantaneous changes in value of the option position. The hedge ratio depends on the option's delta. It changes as the delta changes. If done properly, delta hedging produces results comparable to selling the currency forward. You remove upside and downside risk.

Delta, δ , shows how the value (i.e., the price or premium or cost) of the option changes in response to *small* changes in the underlying exchange rate. It is calculated as the change in the option premium divided by the change in the exchange rate:

$$\delta = \frac{\Delta P}{\Delta E} = \frac{P_1 - P_0}{E_1 - E_0}$$

where:

ΔP = change in the option premium

ΔE = change in the exchange rate

Delta indicates the number of options to purchase to hedge translation risk. Specifically, for every unit of currency we should hold $(-1/\delta)$ put options.

Example: Currency delta hedge

Assume we hold a portfolio valued at €1,000,000, the current spot rate is \$1.2888/€, and at-the-money euro puts sell for \$0.04 with a delta of -0.87 . Calculate (1) the appropriate number of put options to purchase to construct a delta hedge and (2) the adjustment to the delta hedge if the exchange rate changes from \$1.2888 to \$1.276.

Answer:

- (1) We know the appropriate number of options to purchase is equal to $(-1/\delta)$ multiplied by the number of currency units:*

$$\text{euro put option contracts} = \frac{-1}{-0.87} \times \frac{1,000,000}{62,500} = 18.39$$

*One currency option contract on the Philadelphia exchange calls for delivery of €62,500, which equals the number of put options in each contract.

For the Exam: If you should have to calculate the number of puts to delta hedge a holding in a foreign currency, the exam question will have to give you the currency units per put and the result will be a whole number. Alternatively, they may ask for the strategy (i.e., purchase the appropriate number of puts) and the *approximate* number of put contracts. Then you may well be asked to adjust the delta hedge as in this example.

- (2) By rearranging the original equation for delta, we see that the change in the premium is delta multiplied by the change in the exchange rate:

$$\text{delta}(E_1 - E_0) = (P_1 - P_0)$$

The exchange rate changed from 1.2888 to 1.2760, which is \$0.0128, so the premium will change \$0.011136 ($= 0.0128 \times 0.87$) to ~\$0.0511.



Professor's Note: Remember, all prices represent dollar selling prices for euros (U.S. dollars per euro). Having an option to sell every euro for 1.2888 dollars (the exercise price) when the spot rate is 1.276 dollars represents a gain. Therefore, the value of the put option will increase.

To check whether we purchased the correct number of options, we compare the gain in the options position to the translation loss:

- The gain in the options position is the number of options multiplied by the gain per option = $1,149,425 \times \$0.011136 = \$12,800$. The 1,149,425 was calculated as number of contracts multiplied by contract size, or $18.39 \times 62,500$. In reality, the number of contracts would have to be rounded and this would not work out so well. We are using partial contracts to illustrate how it works in concept.
- The translation loss is the change in the spot rate multiplied by the foreign exchange position = $(\$1.2760 - \$1.2888) \times €1,000,000 = -\$12,800$.

Now, we must determine if any adjustment to our delta hedge is required. We'll assume that after the exchange rate movement, the delta changed to -0.90 . We know that we must have $(-1/8)$ multiplied by the number of currency units for a delta hedge.

This means that given the change in exchange rates, the number of option contracts to hold is:

$$\# \text{ put option contracts} = \frac{-1}{-0.90} \times \frac{1,000,000}{62,500} = 17.78$$

Because we hold 18.39 option contracts, we can sell the excess 0.61 option contracts.

Professor's Note: Delta gives us the number of put options to hold (i.e., the hedge ratio) to insure against a 1-time, very small change in exchange rates. Unlike naive futures hedging where the hedge ratio is always 1.0 (i.e., hedge the principal), delta changes every time the underlying exchange rate changes. This means we must continually adjust the delta hedge. The transaction costs associated with buying and selling options can be significant, so the manager will weigh the costs of adjusting the delta hedge against the risks of not adjusting and remaining temporarily under- or over-hedged.



Futures or Options?

After reading the examples of hedging with futures and insuring with options, you may naturally ask under which conditions you should prefer one over the other. The answer is, typically, "it depends."

First, options for a premium provide insurance against unfavorable exchange rate movements. If the currency moves against the investor, the gain in the value of the option should compensate for the loss. If the currency moves favorably, the investor does not have to exercise the option. He instead capitalizes on the gain.

Futures, on the other hand, represent hedging. They remove translation risk by protecting the investor against losses on the amount hedged (e.g., the principal), but they also eliminate any chance of a gain from favorable movements. They are, however, very liquid and are less expensive to use.

Whether to use options or futures actually depends on the manager's expectations. If the manager expects exchange rates to be quite volatile but has no strong feeling for the direction they will go, he should use options. If rates move unfavorably, he can exercise the options. If rates move favorably, he can capitalize on the currency gain. If, on the other hand, the manager is primarily concerned with unfavorable movements, he will use futures, which are cheaper.

INDIRECT CURRENCY HEDGING

LOS 35.h: Discuss and justify methods for managing currency exposure, including the indirect currency hedge created when futures or options are used as a substitute for the underlying investment.

CFA® Program Curriculum, Volume 5, page 286

Currency exposure is the amount of currency the manager must expose to translation risk (i.e., the amount of currency the manager must invest) to achieve the desired strategy. For example, a manager can increase the risk of a foreign portfolio without increasing the currency exposure by buying stocks with higher betas or bonds with longer durations. In this way, the manager makes the portfolio more sensitive to local macroeconomic factors without increasing the currency exposure.

Another way to manage (minimize) currency exposure is buying options or futures on the foreign assets, instead of the assets themselves. For example, assume a manager wishes to purchase a foreign stock index. The manager has two choices: (1) buy all or a representative sample of the stocks in the index or (2) buy futures or options on the foreign index.

If the manager selects the first alternative and purchases many different stocks denominated in the same currency, the manager has the entire value of the stocks exposed to currency movements. Then, any profits on the stocks are further exposed as we discussed earlier.

Instead, if the manager chooses to purchase foreign equity index futures, the manager has only the initial margin committed (i.e., exposed to translation risk).

Options on foreign assets work in the same way. That is, only the option premiums are exposed to translation risk. The premium, and the margin on the foreign index futures, can be hedged if so desired. This ability to realize the gains on the underlying foreign assets by purchasing options or futures is sometimes referred to as *indirect currency hedging* because the investor can enjoy the profits associated with the assets without incurring the currency exposure.

CURRENCY MANAGEMENT

LOS 35.i: Discuss the major types of currency management strategies specified in investment policy statements.

CFA® Program Curriculum, Volume 5, page 290

There are three primary approaches to managing the currency exposure in an international portfolio: (1) strategic hedge ratio, (2) currency overlay, and (3) currency as a separate asset allocation.

Strategic hedge ratio. The investment manager is given total responsibility for managing the portfolio, including managing the currency exposure. The manager follows the

guidelines of the investor's IPS, which will specify whether the portfolio is to be benchmarked and the degree to which currency exposure must be hedged.

Currency overlay. The currency overlay approach still follows the IPS guidelines, but the portfolio manager is not responsible for currency exposure. Instead, a separate manager, who is considered an expert in foreign currency management, is hired to manage the currency exposure within the guidelines of the IPS. That is, the portfolio, including the currency exposure, is managed by two managers to adhere to the IPS guidelines.

Separate asset allocation. When currency is considered a separate asset, it is managed as if it were a totally separate allocation given to a separate manager and managed under its own, separate guidelines. Effectively, this is a currency play with an absolute return benchmark.

KEY CONCEPTS

LOS 35.a

An investor can hedge currency exposure by selling foreign exchange futures. If the future value of an investment is uncertain, the investor may choose to hedge only the amount that was originally invested. This method is also known as hedging the principal.

LOS 35.b

To minimize the variability in the expected return, the global investor can determine the minimum-variance hedge ratio, h , which is divided into two components: translation risk and economic risk. We determine h by regressing the domestic, unhedged return on the asset (or portfolio) on the futures return. The minimum variance hedge ratio is the resulting slope coefficient.

Translation risk is the uncertainty in the actual amount that will be received when the foreign investment is “translated” back into the domestic currency. The principal value of the foreign asset is translated at the prevailing exchange rate, so any change in the exchange rate affects the value of the asset when stated in terms of the domestic currency.

Economic risk is separate from and in addition to translation risk. It occurs when the value of a foreign investment moves in reaction to a change in exchange rates.

LOS 35.c

Basis is the difference between the spot and futures exchange rates at a point in time. The magnitude of the basis depends upon the spot rate and the interest rate differential between the two economies. *Interest rate parity* describes the relationship between spot and futures exchange rates and local interest rates:

$$\frac{F_{D/L}}{S_{D/L}} = \frac{1 + i_D}{1 + i_L}$$

If the ratio of the interest rates should change, the ratio of the futures rate to the spot rate changes accordingly. If, for example, the domestic interest rate increases relative to the local rate, the futures rate also increases (i.e., the domestic currency depreciates relative to the local currency).

LOS 35.d

The first concern associated with the length of the contract is basis risk. The only way to avoid basis risk is to enter a contract (e.g., futures, swap, forward) with a maturity *equal* to the desired holding period. Only then does the investor lock in a rate of exchange for a long currency position (i.e., eliminate basis risk).

When the futures contract is *longer* (i.e., has a longer maturity) than the desired holding period, the investor must reverse at the end of the holding period at the existing futures price. The futures price at that time is dependent upon the relationship of the interest rates in the two countries. Because that relationship may have changed after the implementation of the hedge, the basis may have also changed. Thus, if the investor selects a long-term futures contract (i.e., longer than the desired holding period), he faces basis risk.

If the futures contract is *shorter* than the desired holding period, the investor must close (i.e., reverse out of) the first contract and then enter another. Because they are two distinctly different contracts, the investor faces a risk very similar to that faced by the investor who selects the long-term futures contract. That is, the first futures contract will converge to the spot rate at its maturity. The investor must reverse out of that contract and select another contract whose price will depend upon the existing relationship of the interest rates in the two countries. At the inception of the original contract, therefore, the investor is unsure of the futures price he will get with the second contract. Of course if after the first contract matures no contract exists with a maturity equal to the remaining holding period, the investor must decide whether to enter another short-term contract or a long-term contract.

LOS 35.e

Currency futures and forward contracts are not always actively traded, so hedging the movements in some of the currencies in a multi-currency portfolio may be difficult and inefficient. In these cases it may be desirable to use a cross hedge.

To determine the optimal hedge ratio for a multi-currency portfolio, the manager can perform a sort of returns-based style analysis. Rather than attempt to determine an optimal hedge ratio for each individual currency, the manager can regress the portfolio's historic domestic currency returns on the futures returns for a few major, actively-traded currencies.

$$R_D = \alpha + h_1 F_1 + h_2 F_2 + h_3 F_3 + e$$

where:

h_i = optimal hedge ratio for currency i

F_i = return on currency future i

LOS 35.f

The primary benefit to using currency options rather than futures to protect against translation losses is the relative nature of their payoffs. The payoff to a futures contract is *symmetric*. That is, the investor must reverse out of the contract whether the currency appreciates or depreciates.

A put option is used like *insurance* because it gives the holder the right to sell the currency at a specified price over a specified time period. If the local currency depreciates in value, the gain on the put offsets the loss. If the local currency appreciates, however, the investor allows the option to expire, trades in the spot market, and realizes the gain. This ability to gain on the upside while protecting against the downside comes at the cost of the premium (a sunk cost). That is, the premium is paid regardless of whether the option is exercised.

LOS 35.g

Delta, δ , shows how the value of the option changes in response to *small* changes in the underlying exchange rate. It is calculated as the change in the option premium divided by the change in the exchange rate:

$$\delta = \frac{\Delta P}{\Delta E} = \frac{P_1 - P_0}{E_1 - E_0}$$

where:

ΔP = change in the option premium

ΔE = change in the exchange rate

Delta indicates the number of options to purchase to hedge translation risk. Specifically, for every unit of currency, we should hold $-1/\delta$ put options. It produces results comparable to selling futures contracts.

LOS 35.h

Currency exposure is the amount of currency the manager must expose to translation risk (i.e., the amount of currency the manager must invest) to achieve the desired strategy. For example, a manager can increase the risk of a foreign portfolio without increasing the currency exposure by buying stocks with higher betas or bonds with longer durations. In this way, the manager makes the portfolio more sensitive to local macroeconomic factors without increasing the currency exposure.

An investor can also hedge currency exposure by buying options or futures on foreign assets instead of the assets themselves. This ability to realize the gains on the underlying foreign assets by purchasing options or futures is sometimes referred to as *indirect currency hedging* because the investor can enjoy the profits associated with the assets without incurring the currency exposure.

LOS 35.i

Under a strategic hedge ratio, the investment manager is given total responsibility for managing the portfolio, including managing the currency exposure. The manager follows the guidelines of the investor's investment policy statement (IPS).

The currency overlay approach still follows the IPS guidelines, but the portfolio manager is not responsible for currency exposure. Instead, a separate manager is hired to manage the currency exposure within the guidelines of the IPS. That is, the portfolio, including the currency exposure, is managed by two managers to adhere to the IPS guidelines.

In a separate asset allocation approach, when currency is considered a separate asset, it is managed as if it were a totally separate allocation given to a separate manager and managed under its own, separate guidelines. Effectively, this is a currency play with an absolute return benchmark.

Study Session 14

Adam Graham is a currency overlay manager with Curtis Global Investments, which is based in the United States. Graham is responsible for hedging the currency exposure of one of Curtis's investments in Great Britain valued at £1,500,000. The spot exchange rate at the time of the investment was \$1.89/£ and the futures rate was \$1.91/£. 180 days later the investment is liquidated, realizing a return of 6%. The spot exchange rate at the time of liquidation is \$1.85/£ and the futures rate is \$1.87/£.

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5. **Describe** why an investor may choose to hedge an asset with currency options instead of hedging with currency futures.

Use the following information to answer Questions 6 and 7.

Domanick Jackson, a U.S. investor living in Italy, holds a portfolio worth €3,750,000. He will be moving back to the United States shortly and wishes to conduct a delta hedge strategy to mitigate translation risk. The current spot rate is \$1.258/€, and in-the-money euro put options are selling for \$0.10 with a delta of -0.82 . Each euro put option gives the holder the right to sell €100,000.

6. The number of put option contracts Jackson will need to purchase to conduct a delta hedge is *closest* to:
- A. 30.75.
 - B. 47.17.
 - C. 45.73.
7. Assuming the ability to trade partial options contracts, the exchange rate changes to \$1.247/€, and the premium changes to 0.11 per put, the *most appropriate* action for Jackson to take to remain delta hedged is:
- A. sell 4.52 put contracts.
 - B. sell 11.60 put contracts.
 - C. buy 4.52 put contracts.
8. Which of the following statements does not represent an indirect currency hedging strategy? An investor purchases:
- A. options on foreign assets.
 - B. a representative sample of stocks in a foreign index.
 - C. foreign equity index options.

9. The manager of a large diversified global equity portfolio wants to hedge his multiple currency exposures. Of the following statements, which *best* summarizes a likely problem and corresponding solution in this situation?
- The derivatives for some of the currencies in the portfolio may not be actively traded, so the manager should perform a returns-based style analysis to determine the hedge ratios for derivatives on a few actively traded currencies.
 - The derivatives for all major currencies are very liquid, and an appropriate sampling technique is needed to choose a true random sample of currencies in the portfolio for hedging.
 - The derivatives for some of the currencies in the portfolio may not be actively traded, but the relative liquidity is unknown; therefore, an appropriate sampling technique is needed to choose a true random sample of currencies in the portfolio for hedging.
10. For the two approaches to currency management specified in investment policy statements (IPSs) that are indicated below, **identify** whether the approach uses a separate manager and how the approach fits into the IPS.

Approach	Separate manager for currency?	How the approach fits into the IPS
Strategic hedge ratio	Yes No	
Currency overlay	Yes No	

ANSWERS – CONCEPT CHECKERS

1. B The foreign investment realized a return of 6%. Therefore, the investment is currently valued at $1,500,000 \times 1.06 = £1,590,000$. When the investment is translated back into dollars, Curtis receives $£1,590,000 \times \$1.85/£ = \$2,941,500$ on an original investment of $£1,500,000 \times \$1.89/£ = \$2,835,000$.

The unhedged return on the investment in dollars is:

$$R_{D,u} = (\$2,941,500 - \$2,835,000) / \$2,835,000 = 3.76\%$$

Because the dollar strengthened, Curtis will incur a translation loss of $6.0\% - 3.76\% = 2.24\%$.

2. B The return on the British pound futures contract is:

$$R_{Fut} = -[(1.87 - 1.91) \times £1,500,000] = \$60,000$$

The gain on the futures contract is added to the translated dollar gain in the foreign investment of \$106,500 ($= \$2,941,500 - \$2,835,000$) and divided by the original investment value in dollars to obtain the domestic return on the portfolio.

$$R_p = (106,500 + 60,000) / 2,835,000 = 5.87\%$$

3. Even though Graham hedged the principal, the portfolio return is still not the total 6% earned by the investment in the British pound. This is because he hedged only the principal and incurred a translation loss on the 6% increase in the value of the foreign investment. In order to perfectly hedge, Graham would have needed to hedge the entire amount of £1,590,000.
4. C Translation risk is the risk associated with translating the value of the asset back into the domestic currency. The optimal hedge ratio to compensate for translation risk should be equal to one. Economic risk is the risk associated with the relationship between exchange rate changes and changes in asset values in the foreign market. It depends on the covariance of local asset returns and currency movements.
5. For a premium, options provide insurance against unfavorable exchange rate movements. If the currency moves against the investor, the gain in the value of the option should compensate for the loss. If the currency moves favorably, the investor does not have to exercise the option. He instead capitalizes on the gain. An investor may prefer this asymmetric payoff to the symmetric payoff of a futures hedge, because it will offer the ability to gain on the upside while protecting against any adverse exchange rate movements.
6. C The number of options Jackson needs to purchase to hedge translation risk is equal to $(-1/\delta)$. Therefore, the number of put options equals:

$$\# \text{ euros} = \frac{-1}{-0.82} \times 3,750,000 = 4,573,171$$

$$\# \text{ contracts} = 4,573,171 / 100,000 = 45.73$$

7. A Delta changes to $-0.91 = (0.11 - 0.10) / (1.247 - 1.258)$.

When the delta changes, the number of put options needed to delta hedge will decrease to:

$$\# \text{ of put options} = \frac{-1}{-0.91} \times \frac{3,750,000}{100,000} = 41.21$$

Because Jackson originally held 45.73 put options, he can sell 4.52 ($= 45.73 - 41.21$) and maintain his delta hedge.

8. B The ability to realize the gains on the underlying foreign assets by purchasing options or futures is sometimes referred to as indirect currency hedging because the investor can enjoy the profits associated with the assets without incurring the currency exposure. If an investor purchases a representative sample of stocks in an index denominated in the same currency, the investor has the entire value of stocks exposed to currency movements.
9. A A likely problem is that the derivatives for some of the currencies in the portfolio may not be actively traded, so the manager should perform a returns-based style analysis to determine the hedge ratios for derivatives on a few actively traded currencies.
- 10.

Approach	Separate manager for currency?	How the approach fits into the IPS
Strategic hedge ratio	No	The investment manager is given total responsibility for managing the portfolio, including managing the currency exposure. The manager follows the guidelines of the investor's IPS, which will specify whether the portfolio is to be benchmarked and the degree to which translation risk must be hedged.
Currency overlay	Yes	The separate manager is an "expert" in foreign currency management and manages the currency exposure within the guidelines of the IPS. In sum, the portfolio, including the currency exposure, is managed by two managers to adhere to the IPS guidelines.

SELF-TEST: CURRENCY RISK MANAGEMENT

Use the following information for Questions 1 through 6.

Mary Freer is a portfolio manager for the Worldwide Investors Mutual Fund, a U.S. portfolio manager based in New York. Kate McLaughlin, a recent college graduate, is her assistant.

At a lunch meeting, Freer discusses her strategies and concerns regarding the firm's equity and currency exposure in its global portfolio. She states that the managers at the Worldwide Investors Mutual Fund sometimes hedge their assets based on their expectations of macroeconomic variables, such as interest rates or economic growth. Worldwide Investors Mutual Fund portfolio managers that direct foreign investments have the additional concern of currency risk, which is the sensitivity of an investment to changes in exchange rates, measured in the investor's domestic currency. Freer is scheduled to give a presentation the next day that outlines the basic hedging strategy used to offset currency risk and addresses the additional aspects of currency risk, translation risk, and economic risk.

During her presentation the next day, Freer provides the following example. A U.S. portfolio manager holds a portfolio of European stocks, currently worth €300,000. The spot exchange rate is currently \$1.10/€. The portfolio manager enters into a 3-month futures contract on the euro at \$1.15/€. In one week, the value of the portfolio is €320,000, the spot exchange rate is \$1.20/€, and the futures exchange rate is \$1.23/€. Freer assumes that the portfolio manager in this example uses a simple hedge of the principal. She then asks the audience of junior analysts to calculate the hedged and unhedged return in both dollars and euros.

Freer then discusses how the hedge could be improved so that it reduces currency risk. Instead of a simple hedge of the principal, Freer states that the portfolio manager could have used the minimum-variance hedge ratio, where the ratio is derived by regressing the unhedged return on the foreign stock in dollar terms against the return on the futures contract. She states that this is necessary because there is a relationship between an exporter's currency value and its exports, where a currency depreciation is accompanied by a decrease in sales.

The next day, McLaughlin mentions that it is her understanding that basis risk can make the hedging of currency risk difficult. She states that the changes in the relationship between domestic and foreign interest rates can result in a change in the basis, where a decrease in the domestic interest rate would result in an increased value in the domestic currency as reflected in the futures rate. She states that basis risk can be eliminated, however, if the time horizon of the futures contract matches the time horizon of the investment.

Worldwide Investors Mutual Fund has a position in Swiss stocks that Freer would like to hedge. The value of the position is CHF 4,000,000. The option delta is -0.4 , and the size of one option contract is CHF 62,500.

Discussing currency risk management in general, Freer tells McLaughlin that it has been the policy of the Worldwide Investors Mutual Fund to use a strategic hedge ratio approach. She states that this provides the manager total discretion for hedging currency

risk within the guidelines of the investor's investment policy statement. She believes that this approach is optimal.

1. In Freer's European stock example, the unhedged return in dollar terms is *closest* to:
A. 8.4%.
B. 16.4%.
C. 6.7%.
2. In Freer's European stock example, the hedged return in dollar terms is *closest* to:
A. 16.4%.
B. 6.7%.
C. 9.1%.
3. Regarding Freer's statement concerning the minimum-variance hedge ratio, Freer is:
A. correct.
B. incorrect because a currency depreciation would be accompanied by an increase in sales.
C. incorrect because a currency depreciation would be accompanied by an increase in sales and because the ratio is derived by regressing the hedged return on the foreign stock in dollar terms against the return on the futures contract.
4. Regarding McLaughlin's statement concerning basis risk, McLaughlin is:
A. incorrect because basis risk cannot be eliminated.
B. correct.
C. incorrect because a decrease in the domestic interest rate would result in a decreased value in the domestic currency in the futures rate and because basis risk cannot be eliminated.
5. The *best* strategy for Worldwide Investors Mutual Fund to use to hedge the currency risk of the Swiss stock position is:
A. buy 64 Swiss franc put contracts.
B. buy 160 Swiss franc call contracts.
C. buy 160 Swiss franc put contracts.
6. Regarding Freer's statement concerning the strategic hedge ratio approach, Freer is:
A. incorrect because under a strategic hedge ratio approach, the currency risk is managed separate from the rest of the portfolio.
B. incorrect because under a strategic hedge ratio approach, the currency risk is managed separate from the rest of the portfolio rate and because she is describing a currency overlay approach.
C. correct.

SELF-TEST ANSWERS: CURRENCY RISK MANAGEMENT

1. B The return on the unhedged portfolio in dollars factors in the beginning and ending spot rates:

$$\text{The portfolio return in dollars} = (\text{€}320,000 \times \$1.20/\text{€}) - (\text{€}300,000 \times \$1.10/\text{€}) / (\text{€}300,000 \times \$1.10/\text{€}) = (\$384,000 - \$330,000) / \$330,000 = 16.4\%.$$

Both the investment in euro terms and the euro itself increased in value. The investor benefited from both.

2. C In a simple hedge of the principal, the manager would hedge the €300,000 principal. The manager shorts the euro to hedge the long euro position in the European stock. The loss on the futures contracts in dollars = €300,000 × (\$1.15/€ – \$1.23/€) = –\$24,000.

$$\text{The profit on the unhedged portfolio in dollars is: } (\text{€}320,000 \times \$1.20/\text{€}) - (\text{€}300,000 \times \$1.10/\text{€}) = \$384,000 - \$330,000 = \$54,000.$$

In net, the investor has made a dollar return of $(-\$24,000 + \$54,000) / \$330,000 = 9.1\%$.

3. B Freer is incorrect because currency depreciation is normally accompanied by an increase in sales, as the weaker currency value would make the goods cheaper to foreign importers. The minimum-variance hedge ratio is derived by regressing the unhedged return on the foreign stock in dollar terms against the return on the currency futures contract.
4. B McLaughlin is correct. A decrease in the domestic interest rate would result in an increased value in the domestic currency as reflected in a lower futures rate. This can be observed in the interest rate parity equation with the domestic currency in the numerator and the foreign currency in the denominator. A decreased futures exchange rate means that each unit of foreign currency purchases less domestic currency; thus, the foreign currency has depreciated relative to the domestic currency. Basis risk (due to changes in the spot-futures relationship) can be eliminated, however, if the time horizon of the futures contract matches the time horizon of the investment.
5. C To hedge the currency risk of the Swiss stock position, they should buy puts enabling them to sell CHF 4,000,000 × 1/0.4 = CHF 10,000,000. With CHF 62,500 in one contract, they should buy CHF 10,000,000/(62,500 CHF/contract) = 160 CHF put contracts.
6. C Freer is correct. In a strategic hedge ratio approach, the manager is allowed discretion for hedging currency risk within the guidelines of the investor's investment policy statement. This approach is best because it manages currency risk as an integral part of the portfolio. It allows the manager to view the interaction between the risk of the asset and the currency. The currency overlay approach would assign the currency hedging process to another manager when the portfolio manager does not have the necessary hedging expertise. The overall process is still managed with the guidelines established by the investment policy statement. The currency as a separate asset allocation approach manages currency risk separate from the rest of the portfolio.

RISK MANAGEMENT APPLICATIONS OF FORWARD AND FUTURES STRATEGIES

Study Session 15

EXAM FOCUS

Be able to perform any of the calculations using futures contracts to alter the beta of an equity portfolio, alter the duration of a bond portfolio, change the portfolio allocation among various classes of debt and equity, create synthetic positions, or preinvest an expected cash flow. Your goal is to understand the general concepts and be able to apply them during the exam. Also, be able to explain exposures to exchange rate risk and possible remedies using futures.

WARM-UP: FUTURES AND FORWARDS

The CFA curriculum includes a long section of optional material that has no Learning Outcome Statements and will not be tested directly. It does review how to calculate the number of contracts to modify duration of a fixed income position and you are responsible for those calculations. The formulas are consistent with those covered earlier in the fixed income lesson but are laid out in a different form. We will cover the calculations in this reading assignment and review the formulas needed.

Forward and futures contracts are effective tools for managing both interest rate and equity risks. Although very similar, however, one or the other may be preferred in some cases. The primary differences between the two are that forward contracts can be tailored to meet the specific needs of the counterparties but have higher default risk and less liquidity than futures. In contrast, futures contracts are standardized, so they are less likely to be exactly what the two parties need; however, they trade on an exchange, so the risk of loss from default is minimal.

Forward and futures contracts are zero-sum games, yet they allow a firm to hedge risks for which they have no expertise. A manufacturing firm, for example, should focus on manufacturing and not on profiting from changes in interest rates or exchange rates. Therefore, the firm can use forwards and futures to eliminate the possibility of potential losses and gains (i.e., risk), with which they have little experience.

ADJUSTING THE PORTFOLIO BETA

LOS 36.a: Demonstrate the use of equity futures contracts to achieve a target beta for a stock portfolio and calculate and interpret the number of futures contracts required.

CFA® Program Curriculum, Volume 5, page 309

To modify the beta of an equity portfolio with futures on an equity index, we need to know the beta of the equity portfolio to be hedged or leveraged, as well as the beta of the futures contract. Both betas would be measured with respect to the reference index.

You might ask, “Shouldn’t the beta of the index futures contract equal one?” The answer is no, for two reasons. First, for an index like the S&P 500, it will probably be close to one, but for a more precise hedge, a manager should compute the beta. Second, as seen later, we may wish to adjust exposure with respect to a class of equity (e.g., small-cap stocks) where the beta will be very different from one.

Recall the formula for beta:

$$\beta_i = \frac{\text{Cov}(i,m)}{\sigma_m^2}$$

where:

i = an individual stock, equity portfolio, or equity index

$\text{Cov}(i,m)$ = covariance of returns on asset i with the market

σ_m^2 = variance of the market returns

Having computed our betas and selected a *target beta*, we can find the appropriate number of contracts to sell or buy to hedge or leverage the position (reduce or increase beta), respectively:

$$\text{number of contracts} = \left(\frac{\beta_T - \beta_P}{\beta_f} \right) \left(\frac{V_P}{P_f (\text{multiplier})} \right)$$

where:

β_T = desired portfolio beta

β_P = portfolio beta

β_f = equity futures contract beta

V_P = current value of the portfolio

P_f = futures price



Professor's Note: If you recall the earlier fixed income hedging formula you should recognize this is essentially the same formula but using beta instead of duration as the risk measure. In addition, there is no yield beta for stock.

Example: Adjusting portfolio beta

A manager of a \$5,000,000 portfolio wants to increase the beta from the current value of 0.8 to 1.1. The beta on the futures contract is 1.05, and the total futures price is \$240,000.

Calculate the required number of futures contracts to achieve a beta of 1.1.

Calculate the required number of futures contracts to achieve a beta of 0.0.

Answer:

target beta = 1.1

$$\text{number of contracts} = \left(\frac{1.1 - 0.8}{1.05} \right) \left(\frac{\$5,000,000}{\$240,000} \right) = 5.95$$

The fact that the answer is positive means the appropriate strategy would be to take a long position in six futures contracts. Taking a long position in index futures contracts will increase the beta and *leverage up* the position.

Answer:

target beta = 0.0

$$\text{number of contracts} = \left(\frac{0 - 0.8}{1.05} \right) \left(\frac{\$5,000,000}{\$240,000} \right) = -15.87$$

Shorting 16 contracts would reduce (hedge) the beta of the position to a value close to zero.

The Hedge Isn't Perfect

In both of the previous examples (i.e., leveraging up to 1.1 or hedging down to zero), we had to round to the nearest whole contract. Thus, neither hedge is perfect, and we can expect there to be a deviation from the desired result.

We can hypothesize the following scenario: the reference index (used to calculate the betas) increased in value by 2%, the value of the equity position increased by 1.6%, and the value of the futures price increased by 2.1%. (These values correspond exactly to what we would expect with the provided betas of 0.8 and 1.05.) Had the leveraged position worked as desired (i.e., achieved an effective beta of 1.1), the value of the portfolio would have increased $1.1(0.02) = 2.2\%$ to \$5,110,000:

$$\$5,110,000 = \$5,000,000(1 + 0.022)$$

In our example, where we leveraged up the beta with six contracts, the profit from the futures contract position is \$30,240:

$$\$30,240 = 6(\$240,000)(1.021) - 6(\$240,000)$$

The profit from the equity position itself is \$80,000:

$$\$80,000 = \$5,000,000(1.016) - \$5,000,000$$

Therefore, the final value of the equity portfolio plus futures position is:

$$\$5,110,240 = \$30,240 + \$80,000 + \$5,000,000$$

The return on the position is:

$$0.022048 = (\$30,240 + \$80,000) / \$5,000,000$$

The effective beta on the portfolio proved to be:

$$\text{effective beta} = \frac{\% \Delta \text{ portfolio value}}{\% \Delta \text{ index value}} = \frac{0.022048}{0.020} = 1.1024$$

In this case, the discrepancy was from the fact that we had to do some rounding in the futures position. There is often error from the fact that the portfolio and futures contracts are not perfectly correlated with the index.

INDEX MULTIPLIERS AND SYNTHETIC POSITIONS

The futures price of an equity index is usually the value of the index multiplied by a fixed *multiplier* for that index:

- S&P 500 Index futures trade at 250 times the index value per contract.
- Nasdaq 100 Index futures trade at 100 times the index value per contract.
- DJIA Index futures trade at 10 times the index value per contract.

It is also worthwhile to point out a basic relationship that underlies what we are doing when we replicate synthetic “cash.” We take a short position in futures to offset the risk in a long position in equity. This can be represented as follows:

$$\text{synthetic risk-free asset} = \text{long stock} - \text{stock index futures (i.e., short position)}$$

Also, an investment in a risk-free asset plus a long stock index futures position can replicate a long stock position:

$$\text{synthetic equity} = \text{long risk-free asset} + \text{stock index futures (i.e., long position)}$$

Knowing these two relationships will help you follow the next examples and, more importantly, help you work out the answers on the exam!

SYNTHETIC STOCK INDEX FUND

LOS 36.b: Construct a synthetic stock index fund using cash and stock index futures (equitizing cash).

CFA® Program Curriculum, Volume 5, page 327

The strategies for altering a portfolio beta will work on any position, even if the initial beta is zero. This is the basis of what is known as a *synthetic stock index*. Such a position is usually created from a portfolio of Treasury bills and a long position in equity index futures.

For the Exam: Steps 1 and 2 in the numerical example are most relevant for the exam. Other calculations are presented only to aid your understanding of the underlying process.

Creating a synthetic equity index from a portfolio in T-bills is a 2-step process:

Step 1: We use the value of our T-bill position, T_{held} , in the following equation to determine the unrounded number of equity futures necessary:

$$\text{number of contracts}_{\text{UNrounded}} = \frac{(T_{\text{held}})(1 + R_F)^t}{(P_f)(\text{multiplier})}$$

where:

T_{held} = value of the T-bill position held

R_F = risk-free rate

P_f = futures price

t = time horizon

Professor's Note: We are actually going to suggest you not use this formula. It may lead to the mistaken belief that it is different from the basic hedging formula. It is simply a special case of the basic formula except the amount to hedge is a future value amount. In addition, this formula only applies in limited situations where you start with a zero beta and desire a beta exactly equal to that of the contract or start with a beta on an existing position equal to the contract beta and target zero beta. We will show you how to use the basic formula.



This is an important issue because there are end-of-chapter questions in the CFA curriculum that cannot be solved with the limited-purpose formula above, and you must know how to apply the basic formula in a synthetic situation. Regardless of how you calculate the number of contracts, you can still have the minor rounding issue discussed in Step 2 below.

Step 2: Next, we must recognize the near impossibility of equitizing the exact amount of T-bills held. This is because when we *round* the number of contracts, the actual value of T-bills equitized will be slightly different from the value held. We denote the amount of T-bills equitized as $T_{\text{equitized}}$:

$$T_{\text{equitized}} = \frac{[(\text{number of contracts}_{\text{rounded}})(P_f)(\text{multiplier})]}{(1 + R_F)^t}$$

(This recognizes that we might equitize more or less than the value of T-bills held.)

An investment of $T_{\text{equitized}}$ in T-bills plus “number of contracts_{rounded}” in equity index futures is equivalent to making an investment in:

effective number of units (shares) of stock purchased =

$$\frac{(\text{number of contracts}_{\text{rounded}})(\text{multiplier})}{(1 + \text{dividend yield})^t}$$

Because an investor could simultaneously buy the stock of an equity index and sell futures on that index, the combination of the two must yield the risk-free rate. The price of the index today must be:

$$F_T = S_0(1 + R_F)^T - \text{dividends}$$

That is, the futures price for a contract maturing at time T must be the future value of today's stock prices (at the risk-free rate) less the future value of the dividends not received when you purchase the futures contract. That's why we discount at the dividend rate to arrive at the synthetic position in equity created with the purchase of the index.



Professor's Note: First, subtracting the future value of dividends not received implies that, had you actually held the index stocks instead of index futures, you would have reinvested dividends received in the stocks of the index. Next, subtracting the value of dividends not received (i.e., the benefit/income generated by buying and holding the index stocks) is analogous to subtracting the lease rate or convenience yield in pricing commodity futures. In this case, the dividends are expressed as a dollar amount, so their future value is simply subtracted from the calculated futures price. When we calculated a commodity futures price, we assumed a lease “rate” or convenience “yield” as a percentage of the commodity value, so we incorporated them into the exponent as a percent. Had we assumed continuous compounding and a dividend yield expressed as a percent of the index value, the expression would be equivalent to the one we used for commodities:

$$F_{0,T} = S_0 e^{R_F - d}$$

where:

d = continuous dividend yield

After time period t has passed, the combined movement in the futures contracts and the T-bill position will produce a return equal to that earned by a direct investment of $T_{\text{equitized}}$ in the stocks of the index.

Example: Creating synthetic equity

A manager has \$120 million in Treasury bills with a yield of 3%. For the next six months, the manager wishes to have a synthetic S&P equity position approximately equal to this value. The manager chooses S&P 500 Index futures, and that index has a dividend yield of 2%. The futures price is \$1,100, and the multiplier is \$250.

Calculate the required number of contracts.

Answer:

1. In six months, the bills will be worth:

$$\$120,000,000(1.03)^{1/2} = \$121,786,699$$

2. The manager will purchase 443 futures contracts:

$$N = \frac{\$121,786,699}{(1,100)(\$250)} = 442.86 = 443 \text{ (must be a round number)}$$

3. 443 contracts will actually equitize \$120,037,739.30:

$$\frac{443(1,100)(\$250)}{(1.03)^{1/2}} = \$120,037,739.30$$

We assume the manager purchases an additional \$37,739.30 in T-bills. The dividend yield on the equity index of 2% would be used if we were determining the actual number of units or shares of stock purchased (as shown on the previous page in Step 2 in the second equation) that would be equivalent to the number of equity futures contracts that were bought to gain equity exposure from T-bills.

Professor's Note: In this example, we started with cash and an existing beta of zero. In addition, we implicitly assumed the beta desired and of the contract are the same. Now let's make up a beta for the contract, say 1.05, and use the basic formula to see what happens. The point will be that you could make up any number and as long as the contract and target beta are the same; it will not matter. We would calculate the number of contracts as:



$$N = \left[\frac{(1.05 - 0)}{1.05} \right] \left[\frac{[\$120,000(1.031^{1/2})]}{[(1.100)(250)]} \right] = 442.86 \text{ contracts}$$

This is the same result as in the previous example and if we had arbitrarily picked 0.95 or 1.00 for beta, it would not change that result. However, we will see upcoming examples where you must use the basic formula.

SYNTHETIC CASH

LOS 36.c: Explain the use of stock index futures to convert a long stock position into synthetic cash.

CFA® Program Curriculum, Volume 5, page 331

By offsetting an equity position with equity futures, we can lock in the risk-free rate over a designated time period. In other words, we synthetically change the position from equity to cash. The benefit to using futures is obvious; we can change the nature of the position without having to physically change it.

The required number of equity futures to sell can be determined using:

$$\# \text{ equity contracts} = -\frac{V_P(1 + R_F)^T}{P_f}$$

where:

V_P = value of the equity position

P_f = total futures price (quoted price times multiplier)

R_F = risk-free rate

T = designated period of time

Example: Creating synthetic cash from equity

Assume a pension fund has a \$10 million large-cap position, and fund managers have a bleak outlook for market performance over the next three months, so they want to create synthetic cash approximately equal to the position. Three-month futures are currently at 1,400, with a multiplier of \$250, and 3-month Treasuries are yielding 2.8%. Calculate the appropriate number of contracts and determine the appropriate position in the contracts.

Answer:

To make the \$10,000,000 large-cap position behave like cash (the risk-free asset) over the next three months, fund managers should *sell* approximately 29 futures contracts:

$$\begin{aligned} \# \text{ contracts} &= -\frac{\$10,000,000(1 + 0.028)^{0.25}}{1,400(\$250)} \\ &= -\frac{10,069,276.78}{350,000} = -28.77 \end{aligned}$$

If the managers sell 29 large-cap futures contracts, they will create synthetic cash approximately equal to the value of their position in large-cap equities. Thus, the combination of their equity position and their short position in equity futures will earn the risk-free (cash) rate over the three months.

Example: Required use of the basic hedge formula for a synthetic

Suppose in the example above, it was given that the contract beta is 1.05 and the existing beta for the stocks held is 0.95. Calculate the contracts to sell to create synthetic cash of \$10,000,000.

Answer:

You must use the basic formula and a future value of \$10,000,000 as the amount to hedge.

$$N = \left[\frac{(0 - 0.95)}{1.05} \right] \left\{ \frac{[\$10,000,000(1.028^{1/4})]}{[(1,400)(250)]} \right\} = -26.03 \text{ contracts}$$

Sell 26 contracts.

ADJUSTING THE PORTFOLIO ALLOCATION

LOS 36.d: Demonstrate the use of equity and bond futures to adjust the allocation of a portfolio between equity and debt.

CFA® Program Curriculum, Volume 5, page 335

For the Exam: The command word *demonstrate* can be interpreted as setting up (i.e., determining) the appropriate strategy and then performing the necessary calculations.

Recall the basic equation for altering the beta of the portfolio:

$$\# \text{ equity index contracts} = \left(\frac{\beta_T - \beta_P}{\beta_f} \right) \left(\frac{V_P}{P_f (\text{multiplier})} \right)$$

where:

β_T = desired (target) portfolio beta

β_P = portfolio beta

β_f = equity futures contract beta

V_P = current value of the portfolio

P_f = futures price

Before we can adjust the portfolio allocation, we need to know how to alter the duration of the portfolio.

TARGET DURATION

The number of futures contracts needed to combine with a bond to achieve a targeted portfolio duration is:

$$\text{number of contracts} = (\text{yield beta}) \left(\frac{\text{MD}_T - \text{MD}_P}{\text{MD}_F} \right) \left(\frac{V_P}{P_f (\text{multiplier})} \right)$$

where:

V_P = current value of the portfolio

P_f = futures price

MD_T = target (desired) modified duration

MD_P = modified duration of the portfolio

MD_F = modified duration of the futures

Professor's Note: This formula differs in appearance from that in fixed income but is economically the same. As a refresher, here is the formula from fixed income:

$$\text{number of contracts} = \frac{(D_T - D_P) P_P}{D_{CTD} P_{CTD}} (\text{CTD conversion factor})$$

The differences in appearance are due to the following:

- If yield beta is not given, it is implicitly assumed to be 1.0 and irrelevant. If it is given, include it as a multiplier.
- This reading assignment refers to modified duration and fixed income referred to duration. There is no significance in the terminology difference. This assignment is based on some older literature that predates the wide usage of effective duration. If given a choice, use effective duration for the best measure of duration. More likely you will only be given one form of duration measure, so use what is given.
- P_f (multiplier) is just the full value of the contract. The fixed income reading assignment gave that number directly and used it. This assignment shows you it is calculated as P_f (multiplier).
- Duration of the futures is the same as duration of the CTD bond used in fixed income.
- This reading assignment uses the price of the futures contract while the fixed income assignment used price of the CTD and its conversion factor. The conversion factor is the link between these two prices, making the two formulas identical mathematically.

The bottom line is to know both formulas and use the one for which inputs are given.

Example: Zero duration

A manager has a bond portfolio with a value of \$103,630 and a holding period of one year. The 1-year total futures price is \$102,510. The modified duration of the bond and futures contracts are 1.793 and 1.62, respectively. The yield beta is 1.2.

Calculate the number of contracts to reduce the portfolio duration to 0.



Answer:

$$\text{number of contracts} = (1.2) \left(\frac{0 - 1.793}{1.62} \right) \left(\frac{\$103,630}{\$102,510} \right) = -1.34$$

Assuming he could take partial positions, the manager would short 1.34 contracts to totally hedge (duration = 0) the risk of the portfolio. Another variation of adjusting the duration of a bond portfolio to hedge against an increase in interest rates would be if the manager said he wanted to move a portion or all of the portfolio into *cash*. In this case, the target duration would not be 0 but would instead be approximately 0.25, representing the average duration of a 6-month investment in a cash instrument.

Non-Zero Target Duration

Of course, we can use futures contracts to achieve a duration other than zero.

Example: Adjusting portfolio duration

A manager has a bond portfolio worth \$1,036,300. The total futures price of the appropriate contract is \$102,510. The modified duration of the portfolio is 1.793, and the duration of the futures contract is 1.62. The yield beta is 1.2.

Calculate the number of contracts to reduce duration to 1. **Calculate** the number of contracts to increase duration to 3.

Answer:

To reduce duration to 1:

$$\text{number of contracts} = (1.2) \left(\frac{1 - 1.793}{1.62} \right) \left(\frac{\$1,036,300}{\$102,510} \right) = -5.94 \rightarrow \text{sell six contracts}$$

To increase the duration to 3:

$$\text{number of contracts} = (1.2) \left(\frac{3 - 1.793}{1.62} \right) \left(\frac{\$1,036,300}{\$102,510} \right) = 9.04 \rightarrow \text{buy nine contracts}$$



Professor's Note: Notice that the only real difference between the equations for hedging or adjusting stock or bond is the use of beta or duration as the risk measure. If a yield beta is given for bonds, use it.

Figure 1 is a summary of the steps we will follow in changing the allocations of debt and equity in a portfolio.

Figure 1: Steps for Altering Debt and Equity Allocations

To reallocate an amount from *equity to bonds*:

1. Remove all systematic risk from the position ($\beta = 0$) by shorting equity futures.
2. Add duration to the position ($MD > 0$) by going long bond futures.

To reallocate an amount from *bonds to equity*:

1. Remove all duration from the position ($MD = 0$) by shorting bond futures.
2. Add systematic risk to the position ($\beta > 0$) by going long equity futures.

Example: Altering debt and equity allocations

A manager has a \$50 million portfolio that consists of 50% stock and 50% bonds (i.e., \$25 million each).

- The beta of the stock position is 0.8.
- The modified duration of the bond position is 6.8.

The manager wishes to achieve an effective mix of 60% stock (i.e., \$30 million) and 40% bonds (i.e., \$20 million). Because the move is only temporary, and rather than having to decide which bonds to sell and which stocks to buy to achieve the desired mix, the manager will use futures contracts.

- The price of the stock index futures contract is \$300,000 (including the multiplier), and its beta is 1.1.
- The price, modified duration, and yield beta of the futures contracts are \$102,000, 8.1, and 1, respectively.

Determine the appropriate strategy.

Answer:

Because the manager wishes to increase the equity position and decrease the bond position, the correct strategy is to take a long position in stock index futures and a short position in bond futures.

The manager wants to decrease his bond position by \$5,000,000 (turn \$5,000,000 in bonds into synthetic cash):

$$\begin{aligned} \text{number of bond futures} &= (\text{yield beta}) \left(\frac{MD_T - MD_P}{MD_f} \right) \left(\frac{V_P}{P_f (\text{multiplier})} \right) \\ &= (1) \left(\frac{0.0 - 6.8}{8.1} \right) \left(\frac{\$5,000,000}{\$102,000} \right) = -41.2 \end{aligned}$$

Shorting 41.2 bond futures would make the duration of \$5,000,000 of the portfolio equal to the cash duration of 0.

The manager needs to increase the equity exposure by \$5 million:

$$\begin{aligned}\text{number of equity index futures} &= \left(\frac{\beta_t}{\beta_f} \right) \left(\frac{V_p}{P_f (\text{multiplier})} \right) \\ &= \left(\frac{0.8}{1.1} \right) \left(\frac{\$5,000,000}{\$300,000} \right) \\ &= (0.727)(16.666) = 12.12\end{aligned}$$

12.12 futures contracts would *create* (from the synthetic cash) another \$5,000,000 in equity without changing the portfolio beta. Remember, you can't buy 0.12 contracts, so this is an approximation.

In this example, we would recommend the manager short 41 bond futures contracts and buy 12 stock index futures contracts. In this way, he would synthetically create \$5,000,000 in cash and simultaneously turn it into \$5,000,000 of equity.

ADJUSTING THE EQUITY ALLOCATION

LOS 36.e: Demonstrate the use of futures to adjust the allocation of a portfolio across equity sectors and to gain exposure to an asset class in advance of actually committing funds to the asset class.

CFA® Program Curriculum, Volume 5, page 339

If you have followed the procedures so far, then making synthetic reallocations among equity classes in an equity portfolio will be rather straightforward for you. To transfer \$V from class A to class B, use futures to first transfer \$V in class A to cash and then transfer \$V in cash to class B using index futures.

Example: Changing equity allocations

A manager of \$20 million of mid-cap equities would like to move half of the position to small-cap equities. The beta of the mid-cap position is 1.1, and the average beta of small-cap stocks is 1.5. The betas of the corresponding mid- and small-cap futures contracts are 1.05 and 1.4, respectively. The mid- and small-cap futures total prices are \$244,560 and \$210,500, respectively. **Determine** the appropriate strategy.

Answer:

We should recall our formula for altering beta:

$$\text{number of contracts} = \left(\frac{\beta_t - \beta_p}{\beta_f} \right) \left(\frac{V_p}{P_f(\text{multiplier})} \right)$$

In this case, for the first step where we convert the mid-cap position to cash, $V_p = \$10$ million, and the target beta is 0. The current beta is 1.1, and the futures beta is 1.05:

$$\text{number of contracts}_{\text{mid cap}} = \left(\frac{0 - 1.1}{1.05} \right) \left(\frac{\$10,000,000}{\$244,560} \right) = -42.84$$

The manager should *short* 43 mid-cap index futures to remove the desired amount of mid-cap exposure. Then the manager should take a long position in the following number of contracts on the small-cap index:

$$\text{number of contracts}_{\text{small cap}} = \left(\frac{1.5 - 0}{1.4} \right) \left(\frac{\$10,000,000}{\$210,500} \right) = 50.90$$

Thus, the manager should *buy* 51 small-cap index futures contracts to add the desired amount of small-cap exposure.

PREINVESTING

Preinvesting is the practice of taking long positions in futures contracts to create an exposure that converts a yet-to-be-received cash position into a synthetic equity and/or bond position.

Example: Preinvesting

A portfolio manager knows that \$5 million in cash will be received in a month. The portfolio under management is 70% invested in stock with an average beta of 0.9 and 30% invested in bonds with a duration of 4.8. The most appropriate stock index futures contract has a total price of \$244,560 and a beta of 1.05. The most appropriate bond index futures have a yield beta of 1.00, an effective duration of 6.4, and a total price of \$99,000. Determine the appropriate strategy to preinvest the \$5 million in the same proportions as the current portfolio.

Answer:

The goal is to create a \$3.5 million equity position ($0.7 \times \$5$ million) with a beta of 0.9 and a \$1.5 million bond position ($0.3 \times \$5$ million) with a duration of 4.8:

$$\text{number of stock futures} = \left(\frac{0.9 - 0}{1.05} \right) \left(\frac{\$3,500,000}{\$244,560} \right) = 12.27$$

$$\text{number of bond futures} = (1.0) \left(\frac{4.8 - 0}{6.4} \right) \left(\frac{\$1,500,000}{\$99,000} \right) = 11.36$$

The manager should take a long position in 12 stock index futures and 11 bond index futures.



Professor's Note: In this case, the beta and modified duration of cash are equal to zero because the \$5 million does not represent a current position in either equity or debt.

EXCHANGE RATE RISK

LOS 36.f: Explain exchange rate risk and demonstrate the use of forward contracts to reduce the risk associated with a future receipt or payment in a foreign currency.

CFA® Program Curriculum, Volume 5, page 344

Professor's Note: You are responsible for any of the calculations you see in this section. However, they should not be anything you have not seen before. There is good bit of terminology and you need to know it, recognize its meaning, and perhaps use it properly in constructed response answers.



This section again returns to the concepts of the local market return (LMR) and local currency return (LCR) discussed earlier. It again points out perfect currency hedges of foreign investments are rare, as they require a perfect forecast of the ending value of the foreign investment. A special case exception occurs when both the LMR and LCR are hedged.

Three types of foreign exchange risk are:

1. *Transaction exposure* occurs when a cash flow in a foreign currency will be received or paid at a future date. This can be hedged. If it will be received, sell it forward. If it will be paid, buy it forward.

2. *Economic exposure* is just as real as transaction exposure but less visible initially. It refers to situations when changes in currency value affect business competitiveness and it can have many causes. For example, consider a company that:
- Exports and sells its products in foreign markets. If the domestic currency appreciates, its products become less competitive internationally, leading to a drop in revenue and, likely, in profits and stock price.
 - Purchases and imports from foreign markets items used in the business. If the domestic currency depreciates, costs in domestic currency units increase, leading to lower profits and, likely, in stock price.
 - Only operates domestically with no imports or exports but changes in currency value affects its competitors (or suppliers or customers). Any of these could affect the company's business, profits, and stock price.

Economic exposure is a real risk to cash flow and might be desirable to hedge, but it could also be difficult to quantify and be ongoing. (Hint: this is very similar to the issue of correlation between LMR and LCR and the minimum variance hedge ratio discussed in other reading assignments).

3. *Translation exposure* is the risk of converting foreign denominated financial statements in to domestic currency units. (Hint: you might vaguely remember the two methods taught at Level 2, all current and temporal method. Recall they produce very different results and numbers for the gain or loss. You will not find any examples of hedging translation exposure because it is generally not seen as a real cash flow risk. Of course if a question said here is a number, hedge it, you would do so on the exam).

Derivatives are used most often to hedge *exposure with transaction exposure the one most commonly hedged*:

- Being *long the currency* (in this context) means you have contracted to *receive* the foreign currency. The chief concern is that the foreign currency might depreciate before it is received. For example, assume a U.S. exporter has contracted to sell \$10 million in merchandise for €9 million to a European trade partner, which reflects the current €0.90/\$ exchange rate.

The payment will be made in 60 days, and in that time, the dollar may appreciate to €0.91/\$. In that case, the dollar revenue at that time will be $(€9,000,000)(\$/€0.91) = \$9,890,110$, which is a loss of over \$100,000.

- Being *short the currency* means you have contracted to *pay* the foreign currency, and the concern is that the currency will appreciate. For example, a U.S. importer contracted to purchase €10 million of a foreign good when the exchange rate was €0.9/\$, which translated to a cost of \$11,111,111. If the dollar depreciates to €0.89/\$ before the payment is made, this would increase the dollar cost to \$11,235,955.

In our previous discussion, we showed that transaction exposure can be either long or short. Figure 2 will help you remember the strategy a manager should take to hedge these exposures:

Figure 2: Strategies for Hedging Expected Currency Positions

<i>Contractual Agreement</i>	<i>Position</i>	<i>Action</i>
Receiving foreign currency	Long	Sell forward contract
Paying foreign currency	Short	Buy forward contract

Example: Managing exchange rate risk

Mach, Inc., is a U.S.-based maker of large industrial machines and has just received an order for some of its products. The agreed-upon price is £5 million (British pounds), and the delivery date is 60 days. The current exchange rate is \$1.42 per pound, and the 60-day forward rate is \$1.43 per pound. **Explain** the best way for Mach, Inc., to hedge the corresponding exchange rate risk.

Answer:

On the day the order comes in, Mach, Inc., effectively has a long position in pounds; therefore, it should take a short position in a forward contract. This contract would obligate Mach, Inc., to deliver the pounds that it will receive for dollars. Ideally, the contract would be to exchange the £5,000,000 for:

$$\$7,150,000 = (5,000,000)(\$1.43)$$

According to the contract, in 60 days, Mach will exchange the £5,000,000 for \$7,150,000. If it does not hedge and the realized spot rate in 60 days is \$1.429, Mach will receive only \$7,145,000 = 5,000,000(\$1.429), or \$5,000 less than with the hedged position.

Example: Exchange rate risk

U.S.-based Goblet, Inc., imports wine from France. It has just contracted to pay €8 million for a shipment of wine in 30 days. The current spot rate is €0.8/\$, and the 30-day forward rate is €0.799/\$. **Explain** the strategy Goblet, Inc., could employ to eliminate the exchange rate risk.

Answer:

Because Goblet, Inc., will have to pay euros, it is short the currency and should go long (buy) the forward contract. Goblet, Inc., should enter a forward contract that will allow it to buy the €8,000,000 it will need for the contract for \$10,012,516 = €8,000,000 (\$/€0.799).

What if Goblet, Inc., had not hedged, and the exchange rate is €0.7995/\$ in 30 days? If this is the case, Goblet, Inc., would get the necessary €8 million from converting \$10 million at that spot rate. The dollar cost would be \$10,006,254 = €8,000,000(\$/€0.7995). Thus, without the contract, Goblet, Inc., would have been \$6,262 dollars better off in the spot market.

Discussion

We see that in one case, the firm benefited from the hedged position, and in the other case, the firm was hurt (i.e., suffered an opportunity cost of \$6,262). So why shouldn't firms just take the positives and negatives and let them cancel out over time? Why not try to predict exchange rates and only hedge in those cases where the prediction says that the rates will turn against you? Some firms do this but predicting currency change is risky and takes time and resources. Other firms systematically hedge (or don't hedge) and just focus on the underlying business of the firm.

For the Exam: Currency risk management is earning greater and greater attention in the Level III curriculum as the curriculum turns more and more to a global focus. Be ready to deal with exchange rate risk in both sessions of the exam, as part of an item set in the afternoon or part of a case (i.e., constructed response essay) in the morning.

HEDGING LIMITATIONS

LOS 36.g: Explain the limitations to hedging the exchange rate risk of a foreign market portfolio and discuss two feasible strategies for managing such risk.

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An equity investment in a foreign market has both equity risk and foreign exchange risk. That is, the foreign position will increase or decrease in value according to the activity in the foreign market, and then the domestic investor will face additional return volatility because of the uncertainty caused by fluctuations of the exchange rate. A foreign equity position may increase by 10%, but if the foreign currency depreciates by that much, the net change to the domestic investor is zero.

For the Exam: The hedging limitations addressed in LOS 36.g are similar to those mentioned in Study Session 14, CFA Reading Assignment 35, “Currency Risk Management.” Several additional strategies for dealing with foreign currency risk and foreign market risk are presented in Study Session 17, SchweserNotes Book 5.

The two hedging strategies utilized by global portfolio managers to manage the risk of a foreign-denominated portfolio involve selling forward contracts on the foreign market index (to manage market risk) and selling forward contracts on the foreign currency (to manage the currency risk). They can choose to hedge one or the other, both, or neither. Their four choices can be summed up as follows:

1. Hedge the foreign market risk and accept the foreign currency risk.
2. Hedge the foreign currency risk and accept the foreign market risk.
3. Hedge both risks.
4. Hedge neither risk.

Hedging Market Risk

To hedge the market value (i.e., market risk) of a foreign investment, the manager can short (i.e., sell forward) the foreign market index. The degree to which the portfolio is correlated with the market index will determine the effectiveness of the hedge. If the manager shorts the appropriate amount of the index and it is *perfectly correlated* with the portfolio of investments, the return from the hedging strategy must be the **foreign risk-free rate**.

If the same manager then chooses to hedge the currency risk, she knows the exact value of the foreign currency to hedge, and the return to the (double) hedging strategy must be the manager's **domestic risk-free rate**.

Hedging Currency Risk

An obvious problem faced when trying to hedge the foreign currency risk of a foreign investment is its uncertain future value. Managers use various strategies for managing the currency risk of a foreign portfolio, including:

- Hedging a minimum future value below which they feel the portfolio will not fall.
- Hedging the estimated future value of the portfolio.
- Hedging the initial value (i.e., the principal).

None of these strategies can eliminate all the currency risk. For example, even if management has determined a minimum future value below which the portfolio will not fall, they are still exposed to values above that. If they hedge the principal, portfolio gains are unhedged. A loss in portfolio value would represent an over-hedge (i.e., management has agreed to deliver too much of the foreign currency).

Another proposed strategy is doing nothing (i.e., hedging choice #4 noted previously). As long as the market and currency risks are not highly correlated, changes in the two values will tend to offset one another.

Hedging with Futures or Forwards?

Calculating and constructing the hedge treats futures and forwards interchangeably. There could be occasions when one or the other is favored for practical reasons. Some differences to know are:

- Futures are standardized contracts while forwards can be customized as to amount and expiration date.
- Futures are obligations of the exchange clearinghouse while forwards have counterparty risk.
- Futures are more regulated and transparent, and they require margin.

Empirically:

- Most bond and equity hedging is done with futures even though this usually creates some cross-hedge or basis risk because the futures provide ongoing liquidity and are continually priced.
- Hedging of interest payments or receipts is usually done with forwards (FRAs), so exact amounts and dates can be hedged.
- Likewise, currency hedging generally uses forwards to tailor amounts and dates.
- Eurodollar futures are a very large market but are mostly used by dealers and market makers to hedge their own business needs and positions and not used directly by final customers.

KEY CONCEPTS

LOS 36.a

Having selected a target beta, we can find the appropriate number of contracts to sell or buy to hedge or leverage the position (reduce or increase beta), respectively:

$$\text{number of contracts} = \left(\frac{\beta_T - \beta_P}{\beta_f} \right) \left(\frac{V_P}{P_f (\text{multiplier})} \right)$$

where:

β_T = desired portfolio beta

β_P = portfolio beta

β_f = equity futures contract beta

V_P = current value of the portfolio

P_f = futures price

LOS 36.b

Creating a synthetic equity index from a portfolio in T-bills is a 2-step process:

Step 1: We use the value of our T-bill position, T_{held} , in the following equation to determine the unrounded (i.e., approximate) number of equity futures necessary:

$$\text{number of contracts}_{\text{UNrounded}} = \frac{(T_{\text{held}})(1 + R_F)^t}{(P_f)(\text{multiplier})}$$

where:

T_{held} = value of the T-bill position held

R_F = risk-free rate

P_f = futures price

t = time horizon

Step 2: Next we must recognize the near impossibility of equitizing the exact amount of T-bills held. This is because when we round the number of contracts, the actual value of T-bills equitized will be slightly different from the value held. We denote the amount of T-bills equitized as $T_{\text{equitized}}$:

$$T_{\text{equitized}} = \frac{[(\text{number of contracts}_{\text{rounded}})(P_f)(\text{multiplier})]}{(1 + R_F)^t}$$

(This recognizes that we might equitize more or less than the value of T-bills held.)

An investment of $T_{\text{equitized}}$ in T-bills plus $\text{number of contracts}_{\text{rounded}}$ in equity index futures is equivalent to making an investment in:

effective number of units (shares) of stock purchased =

$$\frac{(\text{number of contracts}_{\text{rounded}})(\text{multiplier})}{(1 + \text{dividend yield})^t}$$

LOS 36.c

By offsetting an equity position with equity futures, we can lock in the risk-free rate over a designated time period. In other words, we synthetically change the position from equity to cash.

The required number of equity futures to sell can be determined using:

$$\# \text{ equity contracts} = -\frac{V_P(1 + R_F)^T}{P_f}$$

where:

V_P = value of the equity position

P_f = total futures price (quoted price times multiplier)

R_F = risk-free rate

T = designated period of time

LOS 36.d

Recall the basic equation for altering the beta of the portfolio:

$$\# \text{ equity index contracts} = \left(\frac{\beta_T - \beta_P}{\beta_f} \right) \left(\frac{V_P}{P_f (\text{multiplier})} \right)$$

The number of futures contracts needed to combine with a bond to achieve a targeted portfolio duration is:

$$\text{number of contracts} = (\text{yield beta}) \left(\frac{MD_T - MD_P}{MD_F} \right) \left(\frac{V_P}{P_f (\text{multiplier})} \right)$$

where:

V_P = current value of the portfolio

P_f = futures price

MD_T = target (desired) modified duration

MD_P = modified duration of the portfolio

MD_F = modified duration of the futures

Note: If not given a value for yield beta, assume it is 1.0.

Steps for Synthetically Altering Debt and Equity Allocations

To reallocate an amount from *equity to bonds*:

1. Remove all systematic risk from the position ($\beta = 0$) by shorting equity futures.
2. Add duration to the position ($MD > 0$) by going long bond futures.

To reallocate an amount from *bonds to equity*:

1. Remove all duration from the position ($MD = 0$) by shorting bond futures.
2. Add systematic risk to the position ($\beta > 0$) by going long equity futures.

LOS 36.e

To transfer \$V from class A to class B, use futures to first transfer \$V in class A to cash and then transfer \$V in cash to class B using index futures.

Recall our formula for altering beta:

$$\text{number of contracts} = \left(\frac{\beta_t - \beta_p}{\beta_f} \right) \left(\frac{V_p}{P_f (\text{multiplier})} \right)$$

For the first step, we convert the position to cash.

The manager should short index futures to remove the desired amount of exposure. Then the manager should take a long position in index futures contracts to add the desired amount of exposure.

Preinvesting is the practice of taking long positions in futures contracts to create an exposure that converts a yet-to-be-received cash position into a synthetic equity and/or bond position.

LOS 36.f

1. Economic exposure is the loss of sales that a domestic exporter might experience if the domestic currency appreciates relative to a foreign currency.
2. Translation exposure refers to the fact that multinational corporations might see a decline in the value of their assets that are denominated in foreign currencies when those foreign currencies depreciate when the consolidated balance sheet is composed.
3. Transaction exposure is the risk that exchange rate fluctuations will make contracted future cash flows from foreign trade partners decrease in domestic currency value or make planned purchases of foreign goods more expensive.

Derivatives are used most often to hedge transaction exposure:

Strategies for Hedging Expected Currency Positions

<i>Contractual Agreement</i>	<i>Position</i>	<i>Action</i>
Receiving foreign currency	Long	Sell forward contract
Paying foreign currency	Short	Buy forward contract

LOS 36.g

An equity investment in a foreign market has both equity risk and foreign exchange risk. That is, the foreign position will increase or decrease in value according to the activity in the foreign market, and then the domestic investor will face additional return volatility because of the uncertainty caused by fluctuations of the exchange rate. A foreign equity position may increase by 10%, but if the foreign currency depreciates by that much, the net change to the domestic investor is zero.

The two hedging strategies utilized by global portfolio managers to manage the risk of a foreign-denominated portfolio involve selling forward contracts on the foreign market index (to manage market risk) and selling forward contracts on the foreign currency (to manage the currency risk). They can choose to hedge one or the other, both, or neither.

CONCEPT CHECKERS

1. The duration of a bond portfolio is 6, and the duration of the most appropriate bond futures contract is 4. The size of the portfolio is 24 times the total futures price. The yield beta of the futures contract is 1. The *most appropriate* strategy to completely hedge the portfolio against changes in interest rates is:
 - A. short 1 futures contract.
 - B. go long 24 futures contracts.
 - C. short 36 contracts.
2. A portfolio manager expects a large cash inflow in the near future and wishes to preinvest the cash flow to earn an equity market return. The *most appropriate* strategy is to:
 - A. take a short position in a stock index futures contract today.
 - B. take a long position in a stock index futures contract today.
 - C. take a short position in a stock index futures contract when the cash is received.
3. A domestic firm experiences a loss of revenue from the loss in sales caused by the recession in a foreign country where its largest purchaser resides. This type of loss is caused by:
 - A. translation risk.
 - B. transaction risk.
 - C. economic risk.
4. Sweat Pants, Inc., a U.S.-based firm, has entered into a contract to import £2,000,000 worth of wool from a firm in Scotland, and the spot exchange rate is \$1.50/£. Management of Sweat Pants wants to alleviate the risk associated with the foreign currency. The forward exchange rate corresponding with the delivery of the wool is \$1.455/£. Which of the following would probably be the *best* tactic to use to alleviate the foreign exchange risk for Sweat Pants?
 - A. Sell £2,000,000 forward and agree to receive \$2,910,000.
 - B. Buy £2,000,000 forward and agree to deliver \$2,910,000.
 - C. Sell £2,000,000 forward and agree to receive \$1,374,570.
5. A French investor has invested in a large, diversified portfolio of Japanese stocks. Which of the following tactics could be used to hedge the investment?
 - A. Buy euros forward and sell the foreign equity index.
 - B. Sell euros forward and sell the foreign equity index.
 - C. Buy euros forward and buy the foreign equity index.

6. Portfolio Management, Inc., (PMI) expects a cash flow of \$10,000,000 in two months. The composition of the PMI portfolio is 40% large-cap equities, 40% small-cap equities, and 20% bonds. Using the following information, **determine** the appropriate strategy for PMI managers to preinvest the \$10,000,000, so that it earns returns equivalent to those of their current positions.
- Large-cap beta = 0.9; small-cap beta = 1.35; bond duration = 6.3; yield beta = 1.0.
 - Large-cap futures beta = 1.0; small-cap futures beta = 1.30.
 - Treasury futures duration = 5.8.
 - Large-cap futures price = \$1,400, multiplier = \$250; (= \$350,000).
 - Small-cap futures price = \$1,100, multiplier = \$250; (= \$275,000).
 - Treasury futures price = \$100,000.
7. A manager has a position in Treasury bills worth \$100 million with a yield of 2%. For the next three months, the manager wishes to have a synthetic equity position approximately equal to this value. The manager chooses S&P 500 Index futures, and that index has a dividend yield of 1%. The futures price is \$1,050, and the multiplier is \$250. **Determine** how many contracts this will require and the *value* of the synthetic stock position.
8. A manager of a \$10,000,000 portfolio wants to decrease the beta from the current value of 1.6 to 1.2. The beta on the futures contract is 1.25, and the total futures price is \$250,000. Using the futures contracts, **calculate** the appropriate strategy.

9. A manager has a \$100 million portfolio that consists of 70% stock and 30% bonds. The manager wishes to achieve an effective mix of 50% stock and 50% bonds.
- The beta of the stock position is 1.2.
 - The modified duration of the bond position is 4.0.
 - The price and beta of the stock index futures contracts are \$225,000 and 1.0, respectively.
 - The price, modified duration, and yield beta of the futures contracts are \$100,500; 5; and 1, respectively.

Determine the appropriate strategy.

10. A manager of \$10 million of large-cap equities would like to shift 25% of the position to mid-cap equities. The beta of the large-cap position is 0.8, and the average beta of mid-cap stocks is 1.2. The betas of the corresponding large and mid-cap futures contracts are 0.75 and 1.25, respectively. The large- and mid-cap total futures prices are \$9,800 and \$240,000, respectively. **Determine** the appropriate strategy.

ANSWERS – CONCEPT CHECKERS

$$1. \quad C \quad \text{number of contracts} = (\text{yield beta}) \left(\frac{-MD_P}{MD_f} \right) \left(\frac{V_P}{P_f (\text{multiplier})} \right) = (1) \left(\frac{-6}{4} \right) (24) = -36$$

Short 36 contracts to hedge the portfolio.

2. B The number of equity index futures is determined by dividing the expected cash position by the total price of the equity index.

3. C This is economic exchange rate risk.

4. B To alleviate the risk associated with moving foreign exchange values, Sweat Pants will enter a forward contract in which they agree to deliver \$2,910,000 = (\$1.455/£) (£2,000,000) and receive the £2,000,000 needed to pay for the wool.

5. A To hedge the investment, the investor could sell the appropriate equity index futures (thus effectively locking in a selling price for his stock in yen) and simultaneously enter a forward contract to deliver the yen for euros.

6. Because the portfolio is currently 40/40/20 large cap, small cap, and bonds, management should assume long positions in futures contracts in those proportions:

40% small cap and large cap = \$4,000,000 each; 20% bonds = \$2,000,000

Management should take long positions in 10 large-cap equity futures, 15 small-cap equity futures, and 22 Treasury futures:

$$\# \text{ equity futures} = \left(\frac{\beta_T - \beta_P}{\beta_f} \right) \left(\frac{V_P}{(P_f)(\text{multiplier})} \right)$$

$$\# \text{ large-cap contracts} = \left(\frac{0.9 - 0}{1.0} \right) \left(\frac{\$4,000,000}{\$350,000} \right) = 10.29$$

$$\# \text{ small-cap contracts} = \left(\frac{1.35 - 0}{1.3} \right) \left(\frac{\$4,000,000}{\$275,000} \right) = 15.10$$

$$\# \text{ Treasury futures} = \beta_{\text{Yield}} \left(\frac{D_T - D_P}{D_f} \right) \left(\frac{V_P}{P_f} \right)$$

$$\# \text{ contracts} = (1) \left(\frac{6.3 - 0}{5.8} \right) \left(\frac{\$2,000,000}{\$100,000} \right) = 21.72$$

7. Buy 383 contracts for a synthetic position of \$100,041,003. First we compute the unrounded number of contracts to *buy* to form our long position:

$$\text{number of contracts}_{\text{Unrounded}} = \frac{(\$100,000,000)(1.02)^{0.25}}{(1,050)(\$250)} = 382.84$$

The unrounded number of contracts is 382.84. We would round this up to 383 to give $V_{\text{rounded}} = [(383)(1,050)(\$250)] / (1.02)^{0.25} = \$100,041,003$. Allocating this much to T-bills with a 2% yield for three months and taking a long position in 383 stock index futures will produce a payoff that is identical to investing that much in the stocks of the index itself.

8. Placing the given values in the formula gives:

$$\text{number of contracts} = \left(\frac{\beta_T - \beta_P}{\beta_F} \right) \left(\frac{V_P}{P_F (\text{multiplier})} \right)$$

$$\text{number of contracts} = \frac{(1.2 - 1.6)(\$10,000,000)}{(1.25)(\$250,000)} = -12.8$$

The manager should take a short position in 13 contracts.

9. Because the manager wishes to decrease the equity position \$20,000,000 and increase the bond position \$20,000,000, the correct strategy is to take a short position in the stock index futures to create a zero beta (synthetic cash) for the appropriate amount of equity and to take a long position in the bond futures to create the appropriate amount of synthetic debt:

$$\text{number of contracts} = \left(\frac{\beta_i - \beta_P}{\beta_F} \right) \left(\frac{V_P}{P_F (\text{multiplier})} \right)$$

$$\text{number of stock futures} = \frac{(-1.2)(\$20,000,000)}{(1.0)(\$225,000)} = -106.67$$

$$\text{number of contracts} = (\text{yield beta}) \left(\frac{MD_T - MD_P}{MD_F} \right) \left(\frac{V_P}{P_F (\text{multiplier})} \right)$$

$$\text{number of bond futures} = (1) \frac{(4 - 0.0)(\$20,000,000)}{(5)(\$100,500)} = +159.20$$

The correct strategy will be to take a short position in 107 stock index futures contracts and a long position in 159 bond futures contracts.

10. The first step is to convert the large-cap position to cash, $V = \$2.5$ million, and the target beta is 0. The current beta is 0.8, and the futures beta is 0.75:

$$\text{number of contracts} = \frac{(0 - 0.8)(\$2,500,000)}{(0.75)(\$9,800)} = -272.11$$

The manager should short 272 of the futures on the large-cap index. Then the manager should take a long position in the following number of contracts on the mid-cap index:

$$\text{number of contracts} = \frac{(1.2 - 0)(\$2,500,000)}{(1.25)(\$240,000)} = 10.0$$

RISK MANAGEMENT APPLICATIONS OF OPTION STRATEGIES

Study Session 15

EXAM FOCUS

As you read through this topic review, you will notice that almost all the LOS are quantitative, but do not just focus on the calculations. Instead, learn the underlying concepts. For example, you might memorize the equations associated with a bull spread as presented in the CFA text and not realize end of chapter questions presume you would have noticed the same result can be achieved in other ways. Interest rate collars have been a favorite on the exam and many candidates are more familiar with options based on price, rather than options based directly on interest rates. Be prepared to work with either. For the exam, be sure you know the construction and payoffs for the strategies as well as their similarities. Be prepared for both item set and constructed response questions and for questions that integrate this material into determining the best solution for a given investor for a given set of facts.

WARM-UP: BASICS OF PUT OPTIONS AND CALL OPTIONS



Professor's Note: The next several pages up to Covered Calls and Protective Puts are review and have only one purpose: you must know the four basic payoff patterns of long or short a call or put and how to compute intrinsic value. These items are the starting point of the material assigned at Level III. Be sure you know it or nothing that follows makes much sense.

Option contracts have asymmetric payoffs. The buyer of an option has the right to exercise the option but is not obligated to exercise. Therefore, the maximum loss for the buyer of an option contract is the loss of the price (premium) paid to acquire the position, while the potential gains in some cases are theoretically infinite. Because option contracts are a zero-sum game, the seller of the option contract could incur substantial losses, but the maximum potential gain is the amount of the premium received for writing the option.

To understand the potential returns, we need to introduce the standard symbols used to represent the relevant factors:

- X = strike price or exercise price specified in the option contract (a fixed value)
- S_t = price of the underlying asset at time t
- C_t = market value of a call option at time t
- P_t = market value of a put option at time t
- t = time subscript, which can take any value between 0 and T , where T is the maturity or expiration date of the option

Call Options

A *call option* gives the *owner* the right, but not the obligation, to buy the stock from the seller of the option. The owner is also called the *buyer* or the holder of the *long position*. The buyer benefits, at the expense of the option *seller*, if the underlying stock price is greater than the exercise price. The option *seller* is also called the *writer* or holder of the *short position*.

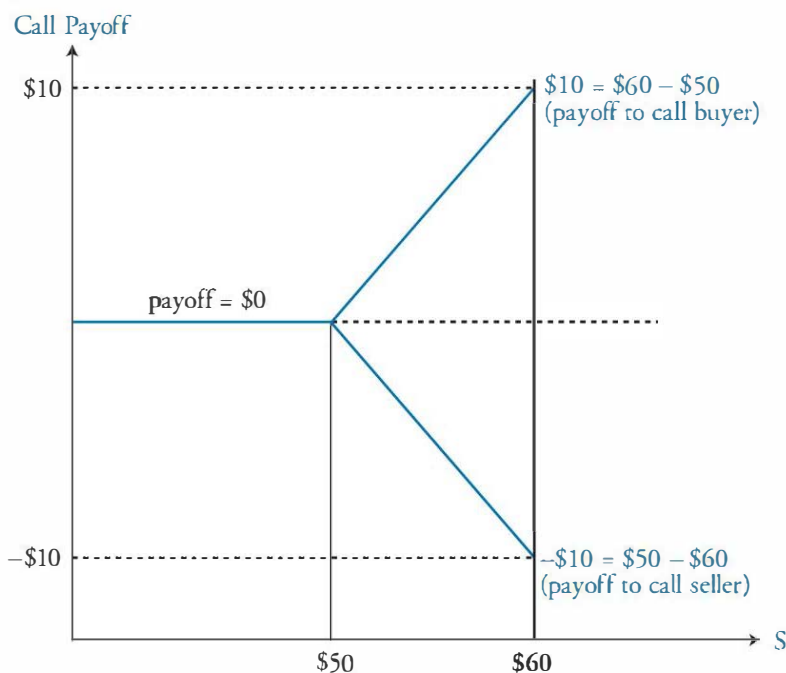
At maturity, time T , if the price of the underlying stock is less than or equal to the strike price of a call option (i.e., $S_T \leq X$), the payoff is zero, so the option owner would not exercise the option. On the other hand, if the stock price is higher than the exercise price (i.e., $S_T > X$) at maturity, then the payoff of the call option is equal to the difference between the market price and the strike price ($S_T - X$). The “payoff” (at the option’s maturity) to the call option seller, which will be at most zero, is the mirror image (opposite sign) of the payoff to the buyer.

Because of the linear relationships between the value of the option and the price of the underlying asset, simple graphs can clearly illustrate the possible value of option contracts at the expiration date. Figure 1 illustrates the payoff of a call with an exercise price equal to 50.



Professor's Note: A payoff graph ignores the initial cost of the option.

Figure 1: Payoff of Call With Exercise Price Equal to 50



Example: Payoff to the writer of a call option

An investor writes an at-the-money call option on a stock with an exercise price of \$50 ($X = \$50$). If the stock price rises to \$60, what will be the *payoff* to the owner and seller of the call option?

Answer:

The call option may be exercised with the holder of the long position buying the stock from the writer at \$50 for a \$10 gain. The payoff to the option buyer is \$10, and the payoff to the option writer is *negative* \$10. This is illustrated in Figure 1, and as mentioned, does not include the premium paid for the option.

This example shows just how easy it is to determine option payoffs. At expiration time T (the option's maturity), the payoff to the option owner, represented by C_T , is:

$$\begin{aligned} C_T &= S_T - X & \text{if } S_T > X \\ C_T &= 0 & \text{if } S_T \leq X \end{aligned}$$

Discussion

Another popular way of writing this is with the “max(0, variable)” notation. If the variable in this expression is greater than zero, then $\max(0, \text{variable}) = \text{variable}$; if the variable's value is less than zero, then $\max(0, \text{variable}) = 0$. Thus, letting the variable be the quantity $S_t - X$, we can write:

$$C_t = \max(0, S_t - X)$$

The payoff to the option seller is the negative value of these numbers. In what follows, we will always talk about payoff in terms of the option owner unless otherwise stated. We should note that $\max(0, S_t - X)$, where $0 < t < T$, is also the payoff if the owner decides to exercise the call option early. In this topic review, we will only consider time T in our analysis. Determining how to compute C_t when $0 < t < T$ is a complex task to be addressed later in this topic review.

Although our focus here is not to calculate C_t , we should clearly define it as the initial cost of the call when the investor purchases at time 0, which is T units of time *before* T . C_0 is the *call premium*. Thus, we can write that the profit to the owner at $t = T$ is:

$$\text{profit} = C_T - C_0$$

This says that at time T , the owner's profit is the option payoff minus the premium paid at time 0. Incorporating C_0 into Figure 1 gives us the profit diagram for a call at expiration, and this is Figure 2.

Figure 2 illustrates an important point, which is that the profit to the owner is negative when the stock price is less than the exercise price plus the premium. At expiration, we can say that:

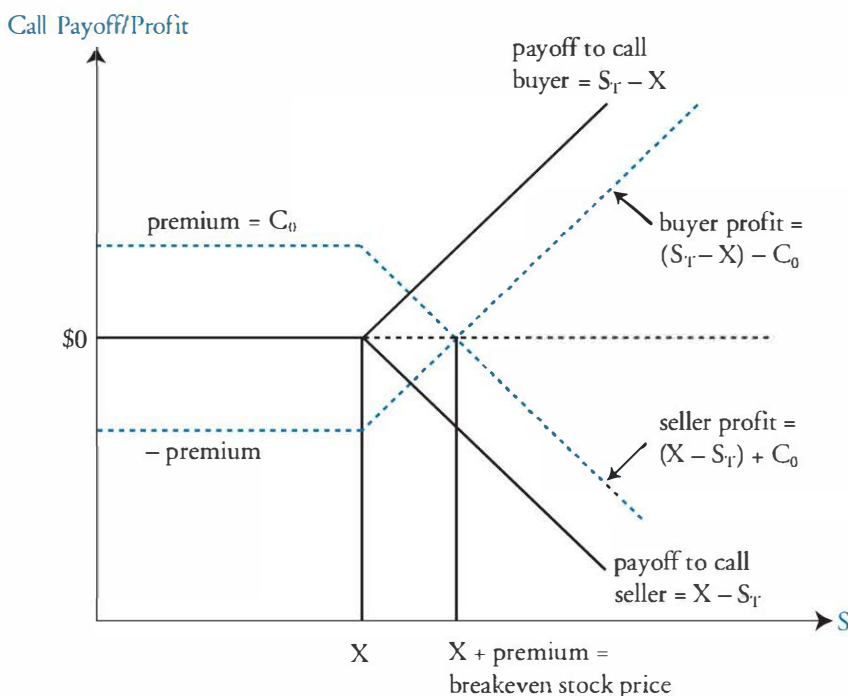
if $S_T < X + C_0$ then: call buyer profit $< 0 <$ call seller profit

if $S_T = X + C_0$ then: call buyer profit $= 0 =$ call seller profit

if $S_T > X + C_0$ then: call buyer profit $> 0 >$ call seller profit

The *breakeven price* is a very descriptive term that we use for $X + C_0$, or $X + \text{premium}$.

Figure 2: Profit Diagram for a Call at Expiration



Put Options

If you understand the properties of a call, the properties of a put should come to you fairly easily. A *put option* gives the owner the right to sell a stock to the seller of the put at a specific price. At expiration, the buyer benefits if the price of the underlying is less than the exercise price X :

$$\begin{aligned} P_T &= X - S_T & \text{if } S_T < X \\ P_T &= 0 & \text{if } X < S_T \end{aligned}$$

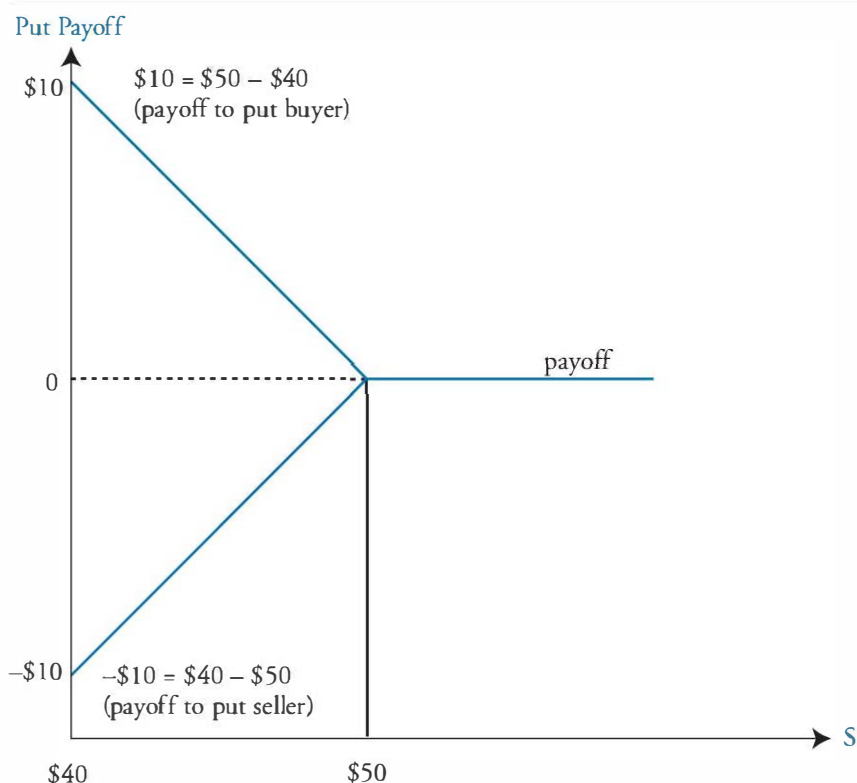
or

$$P_T = \max(0, X - S_T)$$

For example, an investor writes a put option on a stock with a strike price of $X = 50$. If the stock stays at \$50 or above, the payoff of the put option is zero (because the holder may receive the same or better price by selling the underlying asset on the market rather than exercising the option). But if the stock price falls below \$50, say to \$40, the put option may be exercised with the option holder buying the stock from the market at

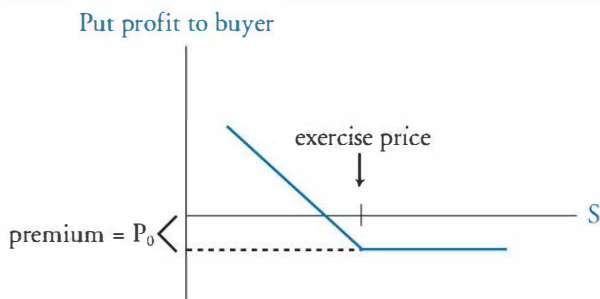
\$40 and selling it to the put writer at \$50, for a \$10 gain. The writer of the put option must pay the put price of \$50, when it can be sold in the market at only \$40, resulting in a \$10 loss. The gain to the option holder is the same magnitude as the loss to the option writer. Figure 3 illustrates this example, excluding the initial cost of the put and transaction costs. Figure 4 includes the cost of the put (but not transaction costs) and illustrates the profit to the put owner.

Figure 3: Put Payoff to Buyer and Seller



Given the “mirror-image quality” that results from the “zero-sum game” nature of options, we often just draw the profit to the buyer as shown in Figure 4. Then, we can simply remember that each positive (negative) value is a negative (positive) value for the seller.

Figure 4: Put Profit to Buyer



The breakeven price for a put position upon expiration is the exercise price minus the premium paid, $X - P_0$.

Example: Call option

An investor purchases a call option on a stock with an exercise price of \$35. The premium is \$3.20. **Calculate** the payoffs and profits for the option owner at expiration for each of the following prices of the underlying stock S_T : \$25, \$30, \$35, \$40, \$45, and \$50. **Calculate** the breakeven price (assuming no transaction costs).



Professor's Note: All examples ignore transactions costs. If by chance you see them on the exam, you can easily include them by just adding any costs onto the option premium in calculating breakeven or profits.

Answer:

The figure below contains the payoffs and profits from a long call with an exercise price of \$35.

Payoff and Profit on a Long Call Option

Stock Price	$\text{payoff} = \max(0, S_T - X)$	$\text{profit} = \text{payoff} - C_0$
\$25	$\max(\$25 - \$35, 0) = \$0$	$\$0 - \$3.20 = -\$3.20$
\$30	$\max(\$30 - \$35, 0) = \$0$	$\$0 - \$3.20 = -\$3.20$
\$35	$\max(\$35 - \$35, 0) = \$0$	$\$0 - \$3.20 = -\$3.20$
\$40	$\max(\$40 - \$35, 0) = \$5$	$\$5 - \$3.20 = \$1.80$
\$45	$\max(\$45 - \$35, 0) = \$10$	$\$10 - \$3.20 = \$6.80$
\$50	$\max(\$50 - \$35, 0) = \$15$	$\$15 - \$3.20 = \$11.80$

As for the breakeven price, we clearly see that it is between \$35 and \$40 because the profit turns positive between these two strike prices. The calculation is simple:

$$\text{breakeven price} = \$35.00 + \$3.20 = \$38.20$$

Example: Put option

An investor purchases a put option on a stock with an exercise price of \$15. The premium is \$1.60. **Calculate** the payoffs and profits for the option owner at expiration for each of the following prices of the underlying stock S_T : \$0, \$5, \$10, \$15, \$20, and \$25. What is the breakeven price?

Answer:

The following table contains the payoffs and profits from a long put with an exercise price of \$15.

Payoff and Profit on a Long Put Option

Stock Price	$\text{payoff} = \max(0, X - S_T)$	$\text{profit} = \text{payoff} - P_0$
\$0	$\max(0, \$15 - \$0) = \$15$	$\$15.00 - \$1.60 = \$13.40$
\$5	$\max(0, \$15 - \$5) = \$10$	$\$10.00 - \$1.60 = \$8.40$
\$10	$\max(0, \$15 - \$10) = \$5$	$\$5.00 - \$1.60 = \$3.40$
\$15	$\max(0, \$15 - \$15) = \$0$	$\$0 - \$1.60 = -\$1.60$
\$20	$\max(0, \$15 - \$20) = \$0$	$\$0 - \$1.60 = -\$1.60$
\$25	$\max(0, \$15 - \$25) = \$0$	$\$0 - \$1.60 = -\$1.60$

We see that the breakeven price is between \$15 and \$10 because the profit turns positive between these two strike prices. The formula is simple:

$$\text{breakeven price} = \$15.00 - \$1.60 = \$13.40$$

These examples illustrate the properties that we have mentioned so far.

- In both cases, the payoffs and profits are linear functions of S_T for the regions above and below X .
- The call option has the potential for an infinite payoff and profit because there is no upper limit to $S_T - X$, nor to $S_T - X - C_0$.
- The put has an upper payoff, which is X , and the upper limit to the profit is $X - P_0$.

Obviously, an investor who thinks the stock will go up would have the propensity to either buy a call or sell a put. An investor that thinks a stock will go down would be motivated to either sell a call or buy a put. Investors can take more elaborate positions, as we will discuss.

COVERED CALLS AND PROTECTIVE PUTS

LOS 37.a: Compare the use of covered calls and protective puts to manage risk exposure to individual securities.

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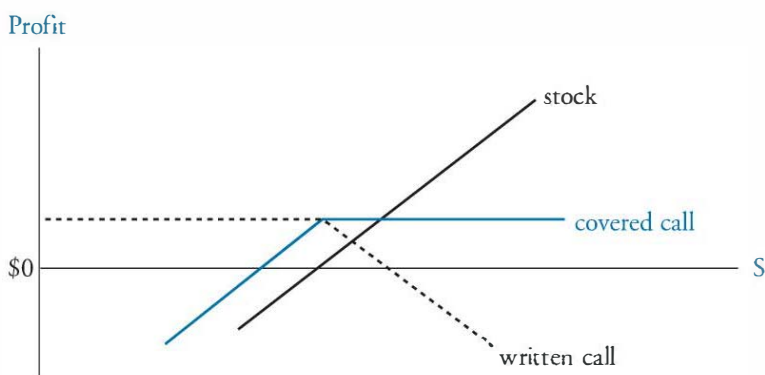


Professor's Note: Covered calls and protective puts are the first of the combined positions. They were taught at Level I and Level II and have been tested at Level III. Know them well.

Covered Call

An investor creates a *covered call* position by buying the underlying security and selling a call option. Covered call writing strategies are used to generate additional portfolio income when the investor believes that the underlying stock price will remain unchanged over the short term. The profit profile for a covered call is given in Figure 5.

Figure 5: Profit Profile for a Covered Call



At expiration, the following relationships hold for the investor that both buys the stock and sells the call:

$$\begin{aligned}\text{profit} &= -\max(0, S_T - X) + S_T - S_0 + C_0 \\ \text{maximum profit} &= X + C_0 - S_0 \\ \text{maximum loss} &= S_0 - C_0 \\ \text{breakeven price} &= S_0 - C_0 \\ S_0 &= \text{initial stock price paid}\end{aligned}$$

For the Exam: Do not take the time to memorize the equations for profit, maximum profit, maximum loss, et cetera, for any of the options strategies unless you honestly feel you have the time. Related exam questions, if any, will probably be worth a relatively small number of points.

Example: Covered call

An investor purchases a stock for $S_0 = \$43$ and sells a call for $C_0 = \$2.10$ with a strike price, $X = \$45$.

- (1) Show the expression for profit and **compute** the maximum profit and loss and the breakeven price.
- (2) **Compute** the profits when the stock price is \$0, \$35, \$40, \$45, \$50, and \$55.

Answer (1):

$$\begin{aligned}
 \text{profit} &= -\max(0, S_T - X) + S_T - S_0 + C_0 \\
 &= -\max(0, S_T - \$45) + S_T - \$43 + \$2.10 \\
 \text{maximum profit} &= X + C_0 - S_0 \\
 &= \$45.00 + \$2.10 - \$43.00 = \$4.10 \\
 \text{maximum loss} &= S_0 - C_0 \\
 &= \$43.00 - \$2.10 = \$40.90 \\
 \text{breakeven price} &= S_0 - C_0 \\
 &= \$43.00 - \$2.10 = \$40.90
 \end{aligned}$$



Professor's Note: You will notice that the maximum loss formulas for the options strategies calculate the absolute value of the loss. In this case, for example, the loss is stated as \$40.90, not -\$40.90.

Answer (2):

The figure below shows profit calculations at the various stock prices.

Covered Call Profits

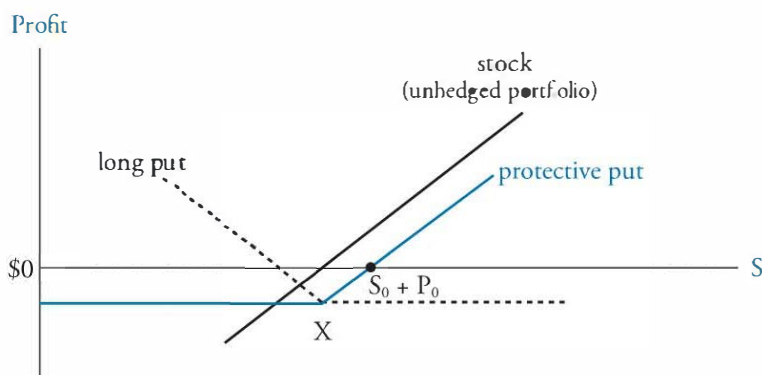
S_T	Covered Call Profits $\text{profit} = -\max(0, S_T - X) + S_T - S_0 + C_0$	
\$0	$-\max(0, \$0 - \$45) + \$0 - \$43.00 + \$2.10$	$= -\$40.90$
\$35	$-\max(0, \$35 - \$45) + \$35.00 - \$43.00 + \$2.10$	$= -\$5.90$
\$40	$-\max(0, \$40 - \$45) + \$40.00 - \$43.00 + \$2.10$	$= -\$0.90$
\$45	$-\max(0, \$45 - \$45) + \$45.00 - \$43.00 + \$2.10$	$= \$4.10$
\$50	$-\max(0, \$50 - \$45) + \$50.00 - \$43.00 + \$2.10$	$= \$4.10$
\$55	$-\max(0, \$55 - \$45) + \$55.00 - \$43.00 + \$2.10$	$= \$4.10$

The characteristics of a covered call are that the sale of the call adds income to the position at a cost of limiting the upside gain. It is an ideal strategy for an investor who thinks the stock will neither go up nor down in the near future. As long as the $S_T > S_0 - C_0$ (\$40.90 in the preceding example), the investor benefits from the position.

Protective Put

A *protective put* (also called *portfolio insurance* or a *hedged portfolio*) is constructed by holding a long position in the underlying security and buying a put option. You can use a protective put to limit the downside risk at the cost of the put premium, P_0 . You will see by the diagram in Figure 6 that the investor will still be able to benefit from increases in the stock's price, but it will be lower by the amount paid for the put, P_0 . The profit profile for a protective put is shown in Figure 6.

Figure 6: Protective Put



At expiration, the following relationships hold:

$$\begin{aligned}\text{profit} &= \max(0, X - S_T) + S_T - S_0 - P_0 \\ \text{maximum profit} &= S_T - S_0 - P_0 \text{ (no upside limit)} \\ \text{maximum loss} &= S_0 - X + P_0 \\ \text{breakeven price} &= S_0 + P_0\end{aligned}$$

Example: Protective put

An investor purchases a stock for $S_0 = \$37.50$ and buys a put for $P_0 = \$1.40$ with a strike price, $X = \$35$.

- (1) **Demonstrate** the expressions for the profit and the maximum profit and **compute** the maximum loss and the breakeven price.
- (2) **Compute** the profits for when the price is \$0, \$30, \$35, \$40, \$45, and \$50.

Answer (1):

$$\begin{aligned}\text{profit} &= \max(0, X - S_T) + S_T - S_0 - P_0 \\ &= \max(0, \$35 - S_T) + S_T - \$37.50 - \$1.40 \\ \text{maximum profit} &= S_T - S_0 - P_0 \\ &= S_T - \$37.50 - \$1.40 = S_T - \$38.90 \\ \text{maximum loss} &= S_0 - X + P_0 \\ &= \$37.50 - \$35.00 + \$1.40 = \$3.90 \\ \text{breakeven price} &= S_0 + P_0 = \$37.50 + \$1.40 = \$38.90\end{aligned}$$

Answer (2):

The figure below shows profit calculations for the protective put.

Protective Put Profits

S_T	Protective Put Profits $profit = \max(0, X - S_T) + S_T - S_0 - P_0$	
\$0	$\max(0, \$35 - \$0) + \$0 - \$37.5 - \$1.40$	$= -\$3.90$
\$30	$\max(0, \$35 - \$30) + \$30.00 - \$37.5 - \$1.40$	$= -\$3.90$
\$35	$\max(0, \$35 - \$35) + \$35.00 - \$37.5 - \$1.40$	$= -\$3.90$
\$40	$\max(0, \$35 - \$40) + \$40.00 - \$37.5 - \$1.40$	$= \$1.10$
\$45	$\max(0, \$35 - \$45) + \$45.00 - \$37.5 - \$1.40$	$= \$6.10$
\$50	$\max(0, \$35 - \$50) + \$50.00 - \$37.5 - \$1.40$	$= \$11.10$

The characteristics of a protective put are that the purchase of the put provides a lower limit to the position at a cost of lowering the possible profit (i.e., the gain is reduced by the cost of the *insurance*). It is an ideal strategy for an investor who thinks the stock may go down in the near future, yet the investor wants to preserve upside potential.

Discussion

The answers here are per one unit of each asset (e.g., one share of stock and one option). The final results can just be multiplied by the number of units involved. For example, in the preceding protective put example, if an investor had 200 shares of the stock and 200 puts, a value of $S_T = 50$ would give a total profit of $200 \times \$11.10$ or \$2,220.

OPTION SPREAD STRATEGIES

LOS 37.b: Calculate and interpret the value at expiration, profit, maximum profit, maximum loss, breakeven underlying price at expiration, and general shape of the graph for the following option strategies: bull spread, bear spread, butterfly spread, collar, straddle, box spread.

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Bull Spread

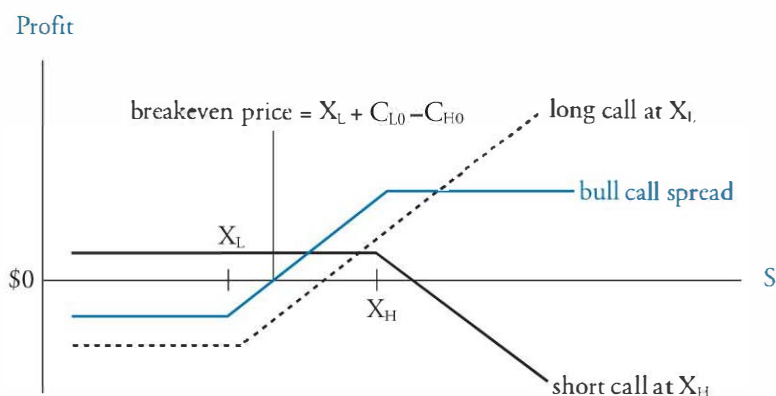
A bull spread provides limited upside if the underlying rises (hence the name bull) with limited downside. It can be constructed when the buyer of the spread purchases a call option with a low exercise price, X_L , and subsidizes the purchase price of that call by

selling a call with a higher exercise price, X_H . The prices are C_{L0} and C_{H0} , respectively. At inception, the following relationships hold:

$$\begin{aligned} X_L &< X_H \\ C_{L0} &> C_{H0} \end{aligned}$$

It is usually the case that $S_0 < X_L$ and almost always that $S_0 < X_H$. The investor who buys a bull spread expects the stock price to rise and the purchased call to finish in-the-money such that $X_L < S_T$. However, the investor does not believe that the price of the stock will rise above the exercise price for the out-of-the-money written call. The profit/loss diagram of a bull spread is shown in Figure 7.

Figure 7: Bull Spread Using Calls



$$\text{profit} = \max(0, S_T - X_L) - \max(0, S_T - X_H) - C_{L0} + C_{H0}$$

$$\text{maximum profit} = X_H - X_L - C_{L0} + C_{H0}$$

$$\text{maximum loss} = C_{L0} - C_{H0}$$

$$\text{breakeven price} = X_L + C_{L0} - C_{H0}$$

Example: Bull spread

An investor purchases a call for $C_{L0} = \$2.10$ with a strike price of $X = \$45$ and sells a call for $C_{H0} = \$0.50$ with a strike price of $X = \$50$.

- (1) **Demonstrate** the expression for the profit and **compute** the maximum profit and loss and the breakeven price.
- (2) **Compute** the profits for when the price is \$0, \$35, \$45, \$48, \$50, and \$55.

Answer (1):

$$\begin{aligned} \text{profit} &= \max(0, S_T - X_L) - \max(0, S_T - X_H) - C_{L0} + C_{H0} \\ &= \max(0, S_T - 45) - \max(0, S_T - 50) - \$2.10 + \$0.50 \\ &= \max(0, S_T - 45) - \max(0, S_T - 50) - \$1.60 \end{aligned}$$

$$\begin{aligned} \text{maximum profit} &= X_H - X_L - C_{L0} + C_{H0} \\ &= \$50.00 - \$45.00 - \$2.10 + \$0.50 \\ &= \$3.40 \end{aligned}$$

$$\begin{aligned}
 \text{maximum loss} &= C_{L0} - C_{H0} \\
 &= \$2.10 - \$0.50 \\
 &= \$1.60
 \end{aligned}$$

$$\begin{aligned}
 \text{breakeven price} &= X_L + C_{L0} - C_{H0} \\
 &= \$45.00 + \$2.10 - \$0.50 \\
 &= \$46.60
 \end{aligned}$$

Answer (2):

The following figure shows the calculations of the profit on the bull spread.

Bull Spread Profits

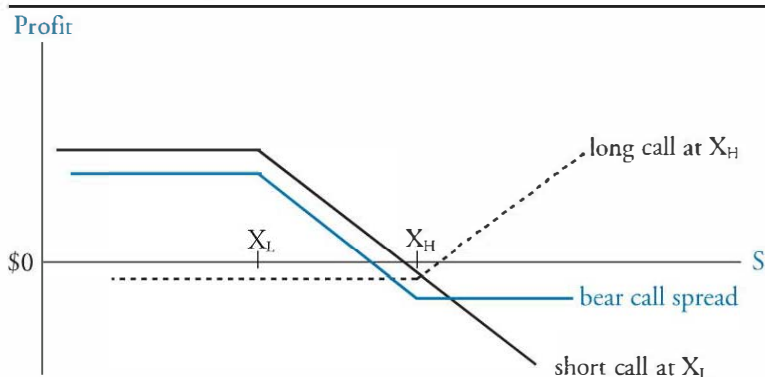
S_T	<i>Bull Spread Strategy</i> $\text{profit} = \max(0, S_T - X_L) - \max(0, S_T - X_H) - C_{L0} + C_{H0}$
\$0	$\max(0, \$0 - \$45) - \max(0, \$0 - \$50) - \$2.10 + \$0.50 = -\$1.60$
\$35	$\max(0, \$35 - \$45) - \max(0, \$35 - \$50) - \$2.10 + \$0.50 = -\$1.60$
\$45	$\max(0, \$45 - \$45) - \max(0, \$45 - \$50) - \$2.10 + \$0.50 = -\$1.60$
\$48	$\max(0, \$48 - \$45) - \max(0, \$48 - \$50) - \$2.10 + \$0.50 = \$1.40$
\$50	$\max(0, \$50 - \$45) - \max(0, \$50 - \$50) - \$2.10 + \$0.50 = \$3.40$
\$55	$\max(0, \$55 - \$45) - \max(0, \$55 - \$50) - \$2.10 + \$0.50 = \$3.40$

The characteristics of a long bull spread (long low exercise call and short high exercise call) are that it provides a potential gain if the stock increases in price but at a lower cost than the single lower exercise-price call alone. The upper limit is capped, however, which is the price of lowering the cost. It is obviously a strategy for an investor with an expectation of the stock's price *increasing in the near term*.

Bear Spread

A bear spread provides limited upside if the underlying declines (hence the name bear) with limited downside. It is most commonly constructed by selling a call with a low strike price and purchasing a call with a high strike price. As stock prices fall, you keep the premium from the written call, net of the long call premium. The purpose of the long call is to protect you from sharp increases in stock prices. The payoff/profits, shown in Figure 8, are the opposite (inverted image) of the bull spread.

Figure 8: Bear Spread



Bear Spread Using Puts

Virtually any payoff pattern can be constructed in more than one way. For example, the bear spread can also be constructed using puts. The investor buys a put with the higher exercise price and sells a put with a lower exercise price. The important relationships are:

$$\begin{aligned}
 \text{profit} &= \max(0, X_H - S_T) - \max(0, X_L - S_T) - P_{H0} + P_{L0} \\
 \text{maximum profit} &= X_H - X_L - P_{H0} + P_{L0} \\
 \text{maximum loss} &= P_{H0} - P_{L0} \\
 \text{breakeven price} &= X_H + P_{L0} - P_{H0}
 \end{aligned}$$

Example: Bear spread using puts

An investor purchases a put for $P_{H0} = \$4.00$ with a strike price of $X_H = \$25.00$ and sells a put for $P_{L0} = \$1.80$ with a strike price of $X_L = \$20.00$.

- (1) **Demonstrate** the expression for profit and **compute** the maximum profit and loss and the breakeven price.
- (2) **Calculate** the profits when the price is \$0, \$15, \$20, \$22, \$25, and \$30.

Answer (1):

$$\begin{aligned}
 \text{profit} &= \max(0, X_H - S_T) - \max(0, X_L - S_T) - P_{H0} + P_{L0} \\
 &= \max(0, 25 - S_T) - \max(0, 20 - S_T) - \$4.00 + \$1.80 \\
 &= \max(0, 25 - S_T) - \max(0, 20 - S_T) - \$2.20 \\
 \\
 \text{maximum profit} &= X_H - X_L - P_{H0} + P_{L0} \\
 &= \$25.00 - \$20.00 - \$4.00 + \$1.80 \\
 &= \$2.80 \\
 \\
 \text{maximum loss} &= P_{H0} - P_{L0} \\
 &= \$4.00 - \$1.80 = \$2.20 \\
 \\
 \text{breakeven price} &= X_H + P_{L0} - P_{H0} \\
 &= \$25.00 + \$1.80 - \$4.00 \\
 &= \$22.80
 \end{aligned}$$

Answer (2):

The following figure shows the calculations of the profits on the bear spread.

Bear Spread Profits

S_T	<i>Bear Spread</i> $profit = \max(0, X_H - S_T) - \max(0, X_L - S_T) - P_{H\theta} + P_{L\theta}$
\$0	$\max(0, \$25 - \$0) - \max(0, \$20 - \$0) - \$4.00 + \$1.80 = \$2.80$
\$15	$\max(0, \$25 - \$15) - \max(0, \$20 - \$15) - \$4.00 + \$1.80 = \$2.80$
\$20	$\max(0, \$25 - \$20) - \max(0, \$20 - \$20) - \$4.00 + \$1.80 = \$2.80$
\$22	$\max(0, \$25 - \$22) - \max(0, \$20 - \$22) - \$4.00 + \$1.80 = \$0.80$
\$25	$\max(0, \$25 - \$25) - \max(0, \$20 - \$25) - \$4.00 + \$1.80 = -\$2.20$
\$30	$\max(0, \$25 - \$30) - \max(0, \$20 - \$30) - \$4.00 + \$1.80 = -\$2.20$

Just like the bull spread, this strategy will benefit for the predicted market move (in this case, a prediction of a down movement), but the gain is limited. The cost is lower, however, because of the sold put with the lower exercise price.

Butterfly Spread With Calls

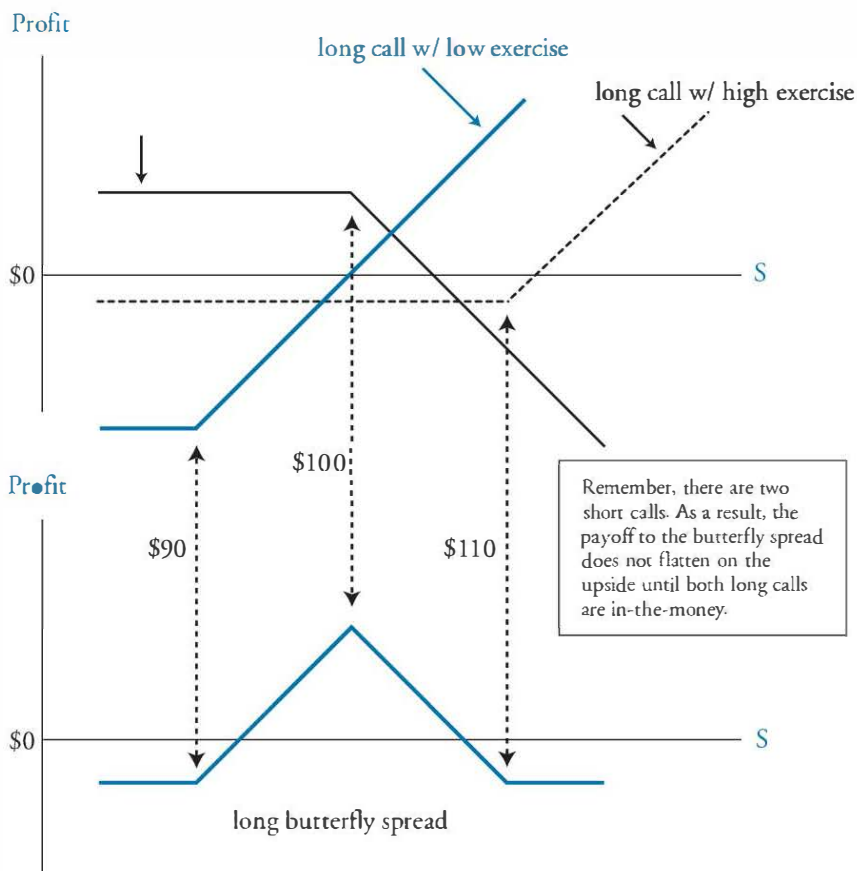
A butterfly spread with calls involves the purchase or sale of four call options of three different types:

- Buy one call with a low exercise price (X_L).
- Buy another call with a high exercise price (X_H).
- Write *two* calls with an exercise price in between (X_M).

Typically the strike prices are equidistant apart, for example 10, 15, and 20.

The buyer of a butterfly spread is essentially betting that the stock price will stay near the strike price of the written calls. However, the loss that the butterfly spread buyer sustains if the stock price strays from this level is not large. The two graphs in Figure 9 illustrate the construction and behavior of a butterfly spread. The top graph shows the profits of the components, and the bottom graph illustrates the spread itself.

Figure 9: Butterfly Spread Construction and Behavior



$$\text{profit} = \max(0, S_T - X_L) - 2\max(0, S_T - X_M) + \max(0, S_T - X_H) - C_{L0} + 2C_{M0} - C_{H0}$$

$$\text{maximum profit} = X_M - X_L - C_{L0} + 2C_{M0} - C_{H0}$$

$$\text{maximum loss} = C_{L0} - 2C_{M0} + C_{H0}$$

$$\text{breakeven prices} = X_L + C_{L0} - 2C_{M0} + C_{H0} \text{ and } 2X_M - X_L - C_{L0} + 2C_{M0} - C_{H0}$$

Example: Butterfly spread with calls

An investor makes the following transactions in calls on a stock:

- Buys one call defined by $C_{L0} = \$7$ and $X_L = \$55$.
- Buys one call defined by $C_{H0} = \$2$ and $X_H = \$65$.
- Sells two calls defined by $C_{M0} = \$4$ and $X_M = \$60$.

(1) **Demonstrate** the expressions for the profit and the maximum profit and **compute** the maximum loss and the breakeven price.

(2) **Calculate** the profits for when the price is \$50, \$55, \$58, \$60, \$62, and \$65.

Answer (1):

$$\begin{aligned}
 \text{profit} &= \max(0, S_T - X_L) - 2\max(0, S_T - X_M) + \max(0, S_T - X_H) \\
 &\quad - C_{L0} + 2C_{M0} - C_{H0} \\
 &= \max(0, S_T - 55) - 2\max(0, S_T - 60) + \max(0, S_T - 65) - \$7 \\
 &\quad + 2(\$4) - \$2 \\
 &= \max(0, S_T - 55) - 2\max(0, S_T - 60) + \max(0, S_T - 65) - \$1
 \end{aligned}$$

$$\begin{aligned}
 \text{maximum profit} &= X_M - X_L - C_{L0} + 2C_{M0} - C_{H0} \\
 &= \$60 - \$55 - \$7 + 2(\$4) - \$2 \\
 &= \$4
 \end{aligned}$$

$$\begin{aligned}
 \text{maximum loss} &= C_{L0} - 2C_{M0} + C_{H0} \\
 &= \$7 - 2(\$4) + \$2 = \$1
 \end{aligned}$$

$$\begin{aligned}
 \text{breakeven prices} &= \$55 + \$7 - 2(\$4) + \$2 \text{ and } 2(60) - \$55 - \$7 + 2(\$4) - \$2 \\
 &= \$56 \text{ and } \$64
 \end{aligned}$$

Answer (2):

The figure shows the calculations of the profits on the butterfly spread.

Butterfly Spread Profits

S_T	<i>Butterfly Spread</i> $\text{profit} = \max(0, S_T - X_L) - 2\max(0, S_T - X_M) + \max(0, S_T - X_H) - C_{L0} + 2C_{M0} - C_{H0}$
\$50	$\max(0, \$50 - \$55) - 2\max(0, \$50 - \$60) + \max(0, \$50 - \$65) - \$1 = -\$1$
\$55	$\max(0, \$55 - \$55) - 2\max(0, \$55 - \$60) + \max(0, \$55 - \$65) - \$1 = -\$1$
\$58	$\max(0, \$58 - \$55) - 2\max(0, \$58 - \$60) + \max(0, \$58 - \$65) - \$1 = \$2$
\$60	$\max(0, \$60 - \$55) - 2\max(0, \$60 - \$60) + \max(0, \$60 - \$65) - \$1 = \$4$
\$62	$\max(0, \$62 - \$55) - 2\max(0, \$62 - \$60) + \max(0, \$62 - \$65) - \$1 = \$2$
\$65	$\max(0, \$65 - \$55) - 2\max(0, \$65 - \$60) + \max(0, \$65 - \$65) - \$1 = -\$1$

Butterfly Spread With Puts

A butterfly spread with puts is constructed by buying one put with a low exercise price, buying a second put with a higher exercise price, and selling two puts with an intermediate exercise price. The profit function is very similar to that of the butterfly spread with calls. You will notice that in each of the $\max(\)$ functions, the S_T and X_i have switched, but otherwise it is basically the same format:

$$\text{profit} = \max(0, X_L - S_T) - 2\max(0, X_M - S_T) + \max(0, X_H - S_T) - P_{L0} + 2P_{M0} - P_{H0}$$

As with the butterfly spread with calls, the long butterfly spread with puts will have its highest terminal value if the stock finishes at the exercise price for the written puts.

Example: Butterfly spread with puts

An investor composes a butterfly spread by buying puts with premiums of \$0.80 and \$5.50 and exercise prices of \$40 and \$50, respectively. The investor sells two puts with a premium of \$3 and an exercise price of \$45. Calculate the profit if the value of the underlying stock at expiration is \$46.30.

Answer:

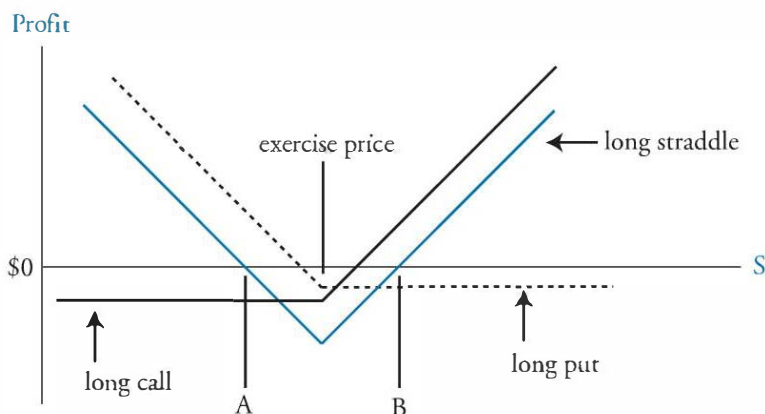
$$\begin{aligned}\text{profit} &= \max(0, \$40.00 - \$46.30) - 2\max(0, \$45.00 - \$46.30) + \max(0, \$50.00 \\ &\quad - \$46.30) - \$0.80 + 2(\$3.00) - \$5.50 \\ \text{profit} &= 0 - 0 + \$3.70 - \$0.30 = \$3.40\end{aligned}$$

The obvious motivation for the butterfly spread is to earn a profit if the underlying asset does not move very much over the lives of the options used to create the spread. If there is a big movement, then the loss is limited to a lower bound (e.g., -\$1 in the first example and -\$0.30 in the butterfly put example—try it and see). Of course, an investor who thinks there will be a big move will take the other side or short the butterfly spread. The butterfly spread's appeal is that it limits the loss to the long side of the strategy.

Straddle

A *straddle* consists of the purchase of both a put option and a call option on the same asset. The put and call are purchased with the same exercise price and expiration. In a straddle, you expect a large stock price move, but you are unsure of the direction. You lose if the stock price remains unchanged. The profit/loss diagram for a straddle is shown in Figure 10.

Figure 10: Straddle



Note that to break even on a straddle, the stock price must move enough to recoup the premiums paid for the options. The breakeven price is equal to the exercise price $\pm$ (put + call premium), denoted by points A and B in Figure 10.

For the *straddle*, the important relationships are:

$$\begin{aligned}\text{profit} &= \max(0, S_T - X) + \max(0, X - S_T) - C_0 - P_0 \\ \text{maximum profit} &= S_T - X - C_0 - P_0 \text{ (unlimited upside as } S_T \text{ increases)} \\ \text{maximum loss} &= C_0 + P_0 \\ \text{breakeven price} &= X - C_0 - P_0 \text{ and } X + C_0 + P_0\end{aligned}$$

Example: Straddle

An investor purchases a call on a stock, with an exercise price of \$45 and premium of \$3, and a put option with the same maturity that has an exercise price of \$45 and premium of \$2.

- (1) **Demonstrate** the expressions for the profit and the maximum profit and **compute** the maximum loss and the breakeven price.
- (2) **Compute** the profits when the price is \$0, \$35, \$40, \$45, \$50, \$55, and \$100.

Answer (1):

$$\begin{aligned}\text{profit} &= \max(0, S_T - X) + \max(0, X - S_T) - C_0 - P_0 \\ &= \max(0, S_T - \$45) + \max(0, \$45 - S_T) - \$3 - \$2 \\ &= \max(0, S_T - \$45) + \max(0, \$45 - S_T) - \$5\end{aligned}$$

$$\begin{aligned}\text{maximum profit} &= S_T - X - C_0 - P_0 \\ &= S_T - \$45 - \$5\end{aligned}$$

$$\text{maximum loss} = C_0 + P_0 = \$5$$

$$\begin{aligned}\text{breakeven price} &= X - C_0 - P_0 \text{ and } X + C_0 + P_0 \\ &= \$45 - \$5 \text{ and } \$45 + \$5 \\ &= \$40 \text{ and } \$50\end{aligned}$$

Answer (2):

The figure below shows the calculation for the profit on a straddle.

Profits on a Long Straddle

S_T	<i>Straddle</i> $\text{profit} = \max(0, S_T - X) + \max(0, X - S_T) - C_0 - P_0$
\$0	$\max(0, \$0 - \$45) + \max(0, \$45 - \$0) - \$3 - \$2 = \$40$
\$35	$\max(0, \$35 - \$45) + \max(0, \$45 - \$35) - \$5 = \$5$
\$40	$\max(0, \$40 - \$45) + \max(0, \$45 - \$40) - \$5 = \$0$
\$45	$\max(0, \$45 - \$45) + \max(0, \$45 - \$45) - \$5 = -\$5$
\$50	$\max(0, \$50 - \$45) + \max(0, \$45 - \$50) - \$5 = \$0$
\$55	$\max(0, \$55 - \$45) + \max(0, \$45 - \$55) - \$5 = \$5$
\$100	$\max(0, \$100 - \$45) + \max(0, \$45 - \$100) - \$5 = \$50$

The values $S_T = \$0$ and $\$100$ were included in the previous example to illustrate the fact that the upside potential for a long straddle is unlimited, and the downside risk is only the sum of the premiums of the call and put.

For the Exam: It is entirely possible you will get a question on a position that was not directly covered by the readings that will test your ability to apply what you should know and interpret it correctly. Suppose a question asked you to explain a short straddle. This is not in the readings but you should know what a straddle is. A short as used in derivatives is the opposite in the sense that short is the opposite of long. In other words do the opposite of a straddle and think of a reasonable response to the question.

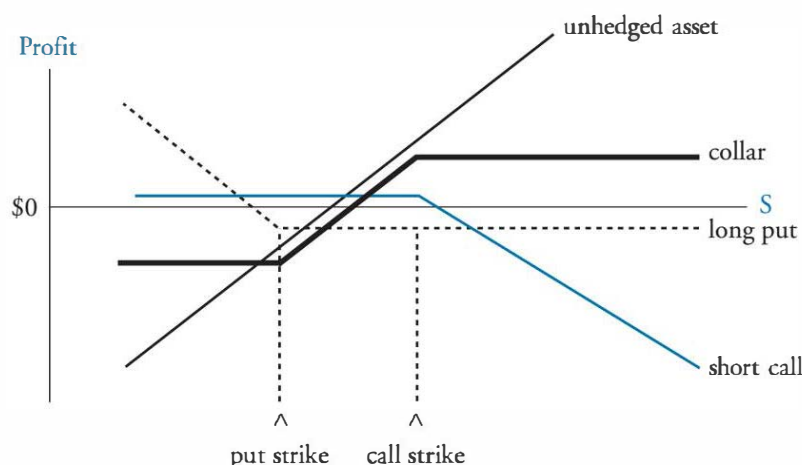
A short straddle is the sale of a put and call on the same underlying asset at the same exercise price and the same maturity. The straddle seller is betting that the stock price will not move much over the horizon of the strategy (i.e., vertically flip Figure 10 in your mind). If the stock price remains unchanged, the options expire out-of-the-money, and the straddle seller keeps the put and call premiums.

Collar

A collar is the combination of a protective put and covered call. The usual goal is for the owner of the underlying asset to buy a protective put and then sell a call to pay for the put. If the premiums of the two are equal, it is called a *zero-cost collar*. The usual practice is to select strike prices such that put strike < call strike. Because this is the case, we can continue to use our X_L and X_H notation where X_L is the put strike price and X_H is the call strike price.

As Figure 11 illustrates, this effectively puts a band or *collar* around the possible returns. Both the upside and downside are limited, the downside by the long put and the upside by the short call. Many possibilities exist. By lowering X_L , for example, the put premium will fall, so the investor could sell a call with a higher X_H to offset the lower put premium. With a lower X_L and higher X_H , the upside and downside potential both increase.

Figure 11: Collar



$$\text{profit} = \max(0, X_L - S_T) - \max(0, S_T - X_H) + S_T - S_0$$

$$\text{maximum profit} = X_H - S_0$$

$$\text{maximum loss} = S_0 - X_L$$

$$\text{breakeven price} = S_0$$

Professor's Note: The CFA text is only covering what is called a zero-cost collar. That means the premium received and paid are equal so no funds are invested initially and the formula for profit can ignore any initial premium received or paid. It was zero. You may want to stop here since the text does not cover non-zero cost collars. To consider a zero-cost collar, the profit is $\max(0, X_L - S_T) - \max(0, S_T - X_H) + S_T - S_0$; that is, the premium paid for the put, P_0 , is exactly offset by the premium received for the call, C_0 . That is, $C_0 - P_0 = 0$. To consider a non-zero cost collar, you would have to include the difference between the price received for the call and the price paid for the put ($C - P$) in each equation. Collars are common when hedging interest rates and you will find discussion of them elsewhere in that context.

Example: Zero-cost collar

An investor purchases a stock for \$29 and a put for $P_0 = \$0.20$ with a strike price of $X_L = \$27.50$. The investor sells a call for $C_0 = \$0.20$ with a strike price of $X_H = \$30$.

- (1) **Demonstrate** the expression for the profit and **calculate** the maximum profit and loss and the breakeven price.
- (2) **Calculate** the profits when the price is \$0, \$20.00, \$25.00, \$28.50, \$30.00, and \$100.00.

Answer (1):

This is a zero-cost collar because the premiums on the call and put are equal.

$$\begin{aligned}\text{profit} &= \max(0, X_L - S_T) - \max(0, S_T - X_H) + S_T - S_0 \\ &= \max(0, \$27.50 - S_T) - \max(0, S_T - \$30.00) + S_T - \$29.00\end{aligned}$$



Professor's Note: If this weren't a zero-cost collar, we would add or subtract the net premium ($C_0 - P_0$) for the put and call.

$$\begin{aligned}\text{maximum profit} &= X_H - S_0 \\ &= \$30 - \$29 \\ &= \$1\end{aligned}$$

$$\begin{aligned}\text{maximum loss} &= S_0 - X_L \\ &= \$29.00 - \$27.50 \\ &= \$1.50\end{aligned}$$

$$\text{breakeven price} = S_0 = \$29$$

Answer (2):

The table on the following page shows the calculations for profits on this zero-cost collar.

Profits on a Zero-Cost Collar

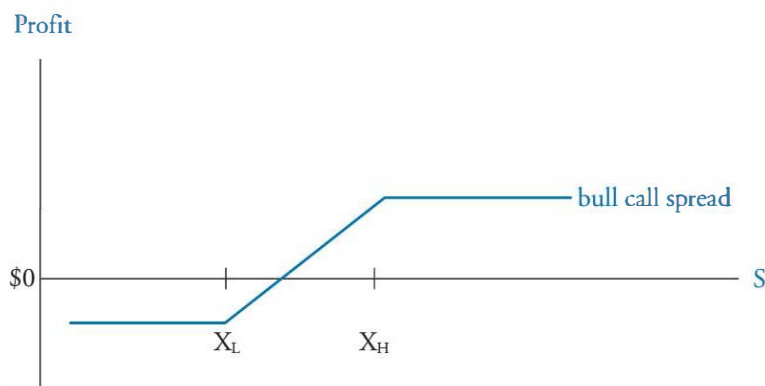
S_T	Zero-Cost Collar $\text{profit} = \max(0, X_L - S_T) - \max(0, S_T - X_H) + S_T - S_0$	
\$0.00	$\max(0, \$27.50 - \$0) - \max(0, \$0 - \$30.00) + \$0 - \$29.00$	= -\$1.50
\$20.00	$\max(0, \$27.50 - \$20.00) - \max(0, \$20.00 - \$30.00) + \$20.00 - \$29.00$	= -\$1.50
\$25.00	$\max(0, \$27.50 - \$25.00) - \max(0, \$25.00 - \$30.00) + \$25.00 - \$29.00$	= -\$1.50
\$28.50	$\max(0, \$27.50 - \$28.50) - \max(0, \$28.50 - \$30.00) + \$28.50 - \$29.00$	= -\$0.50
\$30.00	$\max(0, \$27.50 - \$30.00) - \max(0, \$30.00 - \$30.00) + \$30.00 - \$29.00$	= \$1.00
\$100.00	$\max(0, \$27.50 - \$100.00) - \max(0, \$100.00 - \$30.00) + \$100.00 - \$29.00$	= \$1.00

We see how the lower limit of dollar return is -\$1.50, even when the underlying asset's price is zero. The upper limit on return or profit is \$1, even when the underlying asset's price is \$100. For a price of the underlying asset between the strike prices, such as $S_T = \$28.50$ in this example, the profit is between -\$1.50 and \$1.00. The collar is a good strategy for locking in the value of a portfolio at a minimal cost. The cost is zero if the appropriate put and call have the same premium.

Box Spread Strategy

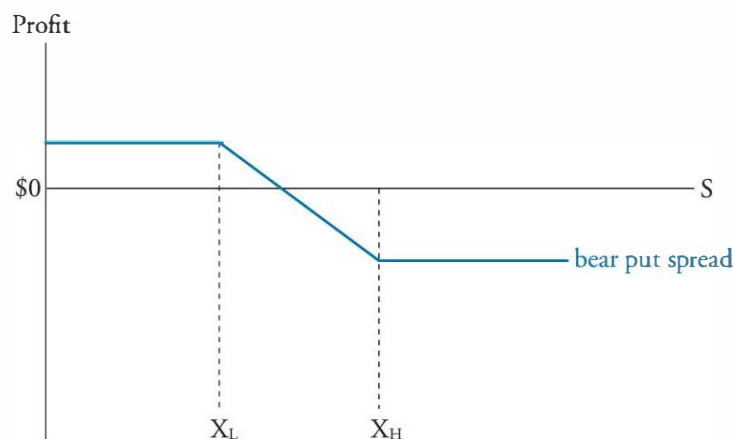
The *box spread* is a combination of a bull call spread and a bear put spread on the same asset. Recall that a bull call spread is the combination of two calls: a short call with a higher strike price (X_H) and a long call with a lower strike price (X_L). (Figure 7 is partially reproduced for your convenience.)

Figure 7: Bull Call Spread (partially reproduced)



The bear put spread is a short put with a lower strike price (X_L) and long put with a higher strike price (X_H). The payoff to a bear put spread is shown in Figure 12.

Figure 12: Bear Put Spread



Professor's Note: Note that by combining a bull call spread and a bear put spread on the same asset you have:

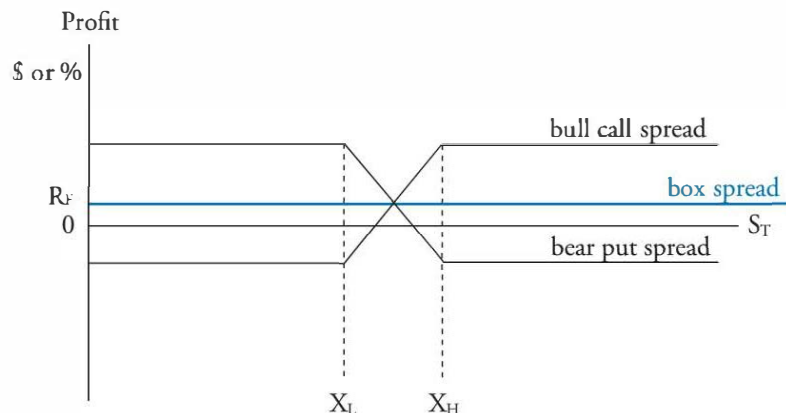


- A long call and a short put with the same lower exercise price (X_L).
- A long put and a short call with the same higher strike price (X_H).

The payoff to combining the bull call and bear put spreads into a *box spread* is shown in Figure 13. You will notice that the payoff is the same, regardless of the value of the underlying asset. That is, the payoff (i.e., profit) to the box spread is always the same,

so if the options are priced correctly, the payoff must be the risk-free rate. If the options are not priced correctly and the box spread return is not the risk-free rate, the box spread has identified an arbitrage opportunity.

Figure 13: Payoff to the Box Spread



Example: Box spread

An investor buys a call and sells a put with a strike price of $X_L = \$25$. The call and put premiums are $C_{L0} = \$1.75$ and $P_{L0} = \$0.50$. The investor then sells a call and buys a put with a strike price of $X_H = \$30$. For the second pair of options, the call and put premiums are $C_{H0} = \$0.20$ and $P_{H0} = \$3.90$. The options all expire in two months.

Compute the profit and the annualized return on the investment and **determine** whether this is a worthwhile investment, if the risk-free rate is 5%.

Answer:

$$\text{profit} = X_H - X_L + P_{L0} - C_{L0} + C_{H0} - P_{H0}$$

$$\text{profit} = \$30.00 - \$25.00 + \$0.50 - \$1.75 + \$0.20 - \$3.90$$

$$\text{profit} = \$0.05$$

The initial cost was $\$4.95 = +\$0.50 - \$1.75 + \$0.20 - \$3.90$. This means the holding period return is $0.05 / 4.95 = 0.0101$. This is a 2-month return, so the annualized return is $0.06216 (= 1.0101^{12/2} - 1)$. Because this return is greater than the risk-free rate of 5%, this would be a worthwhile strategy. If the investor can borrow for less than 0.06216 (6.2%), an arbitrage profit is possible.

INTEREST RATE OPTIONS

LOS 37.c: Calculate the effective annual rate for a given interest rate outcome when a borrower (lender) manages the risk of an anticipated loan using an interest rate call (put) option.

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For the Exam: Be sure you can explain the use of interest rate options as well as calculate their payoffs.

Hopefully, you are already familiar with the basic mechanics of an interest rate call option that makes a payment to the owner when the reference rate (a.k.a. the *underlying*) exceeds the strike rate (i.e., the exercise rate). Because LIBOR is the usual reference rate, we will put that in the formula. The formula for the payment is:

$$\text{payoff} = (NP)[\max(0, \text{LIBOR} - \text{strike rate})](D / 360)$$

where *NP* stands for notional principal and *D* stands for *days in underlying rate* (i.e., the number of days the notional principal would be theoretically borrowed).

NOTE: Do not confuse this with the maturity of the call! *Maturity* is the time between today and when the payoff is determined.

As an example, we will say that the notional principal of the contract is \$20 million, the strike rate is 6%, and *D* = 90 days. If at maturity LIBOR is 6.2%, the payoff would be:

$$\text{payoff} = (\$20,000,000)(0.002)(90 / 360) = \$10,000$$

If the underlying rate (LIBOR) had been less than 6%, then the payoff would have been zero. Because the call has a positive payoff when interest rates rise above a certain level, they can hedge a floating-rate loan.

Example: Interest rate call option

On March 1, a firm plans to borrow \$10 million for 90 days beginning on April 1 (31 days in the future, which is the maturity of the *call*). It can currently borrow at LIBOR plus 200 basis points, and LIBOR is currently 4.5%. The firm buys an interest rate call option where LIBOR is the underlying, and the strike rate is 4%. The notional principal is \$10 million, and *D* = 90 days, which is also the length of the loan. The premium of the call is \$5,000. Calculate the effective borrowing rates of the loan when LIBOR is 2.0%, 3.5%, 4.0%, 4.5%, and 6%.

Answer:

If the manager chooses to purchase the call, that is a cost today. To accurately measure its effect on the borrowing costs, we need to compute its (future) value at the date of the loan, using the firm's cost of borrowing (LIBOR + 0.02):

$$\begin{aligned}\text{FV}(\text{premium}) &= \text{premium}[1 + (\text{current LIBOR} + \text{spread})(\text{maturity} / 360)] \\ \text{FV}(\text{premium}) &= \$5,000[1 + (0.045 + 0.02)(31 / 360)] \\ \text{FV}(\text{premium}) &= \$5,028\end{aligned}$$

Hence, when the firm actually borrows on April 1 (31 days in the future), it is effectively receiving:

$$\begin{aligned}\text{net amount} &= \text{loan} - \text{FV}(\text{premium}) \\ \text{net amount} &= \$10,000,000 - \$5,028 \\ \text{net amount} &= \$9,994,972\end{aligned}$$

With the call premium now reflected in the net proceeds of the loan, the interest cost will be LIBOR plus the 200 basis point spread at that time less any payoff from the call:

$$\begin{aligned}\text{effective dollar interest cost} &= \\ &= \$10,000,000(\text{LIBOR}_{\text{April 1}} + 0.02)(90 / 360) - (\text{call payoff})\end{aligned}$$

The call payoff is:

$$\begin{aligned}\text{payoff} &= (\text{NP})[\max(0, \text{LIBOR} - \text{strike rate})(D / 360)] \\ \text{payoff} &= (\$10,000,000)[\max(0, \text{LIBOR}_{\text{April 1}} - 0.04)(90 / 360)]\end{aligned}$$

The effective annual rate (EAR) of borrowing for the 90 days is:

$$\text{EAR} = [(\$10,000,000 + \text{effective dollar interest cost}) / (\$9,994,972)]^{(365/90)} - 1$$

Let's look at the two extremes first: 2% and 6%. If LIBOR is less than 4%, the call payoff is zero. If LIBOR is 2% on April 1, for example, the effective dollar interest cost is:

$$\$100,000 = \$10,000,000(0.02 + 0.02)(90 / 360)$$

If the firm did not hedge, the effective annual rate would be:

$$\begin{aligned}\text{EAR without hedge} &= (\$10,100,000 / \$10,000,000)^{(365/90)} - 1 \\ \text{EAR without hedge} &= 0.04118\end{aligned}$$

Including the cost of the call will increase the rate to:

$$\begin{aligned}\text{EAR with hedge} &= (\$10,100,000 / \$9,994,972)^{(365/90)} - 1 \\ \text{EAR with hedge} &= 0.04331\end{aligned}$$

Thus, the cost of the call is incorporated into the effective rate of the loan. Just like a purchased call on a stock, if the underlying is below the strike at expiration, the buyer loses (i.e., the option is worthless and the buyer has paid a premium for it).

Where the borrowing firm benefits is when LIBOR is higher than the strike rate. If $\text{LIBOR}_{\text{April 1}} = 6\%$, the option payoff is:

$$\text{payoff} = (\$10,000,000)(0.06 - 0.04)(90 / 360)$$

$$\text{payoff} = \$50,000$$

$$\text{effective dollar interest cost} = \$10,000,000(0.06 + 0.02)(90 / 360) - \$50,000$$

$$\text{effective dollar interest cost} = \$150,000$$

Comparing the EAR with and without the hedge:

$$\text{EAR without hedge} = (\$10,200,000 / \$10,000,000)^{(365/90)} - 1$$

$$\text{EAR without hedge} = 0.08362$$

Including the cost of the call will decrease the effective rate to:

$$\text{EAR with hedge} = (\$10,150,000 / \$9,994,972)^{(365/90)} - 1$$

$$(\text{call payoff} = \$50,000)$$

$$\text{EAR with hedge} = 0.06441$$

In fact, this effective rate of 0.06441 is the highest rate the firm can expect to pay with the call.

Let's look at what happens for the cases in between, where $0.02 < \text{LIBOR}_{\text{April 1}} < 0.06$. If $\text{LIBOR}_{\text{April 1}} = 0.035$, the firm will incur dollar interest costs equal to:

$$\text{effective dollar interest cost} = \$10,000,000(0.055)(90 / 360) = \$137,500$$

because the call expires worthless. The effective rate on the net inflow from the borrowing is:

$$\text{EAR with hedge} = (\$10,137,500 / \$9,994,972)^{(365/90)} - 1 = 0.05910$$

If $\text{LIBOR}_{\text{April 1}} = 0.04$, the firm will incur dollar interest costs equal to:

$$\text{effective dollar interest cost} = \$10,000,000 \times 0.06 \times (90 / 360) = \$150,000$$

because the call expires worthless. The effective rate on the net inflow from the borrowing is:

$$\text{EAR with hedge} = (\$10,150,000 / \$9,994,972)^{(365/90)} - 1 = 0.06441$$

If $\text{LIBOR}_{\text{April 1}} = 0.045$, the firm will earn a payoff on the call:

$$\text{payoff} = (\$10,000,000) \times \max(0, 0.045 - 0.04) \times (90 / 360) = \$12,500$$

The effective dollar interest cost will be:

$$\text{effective dollar interest cost} = \$10,000,000(0.065)(90 / 360) - \$12,500$$

$$\text{effective dollar interest cost} = \$162,500 - \$12,500 = \$150,000$$

The effective rate on the net inflow from the borrowing is:

$$\text{EAR with hedge} = (\$10,150,000 / \$9,994,972)^{(365/90)} - 1 = 0.06441$$

This is the same effective cost for when $\text{LIBOR}_{\text{April 1}} = 0.06$.

Let's try another example with less explanation in the answer.

Example: Interest rate option

In 40 days, a firm wishes to borrow \$5 million for 180 days. The borrowing rate is LIBOR plus 300 basis points. The current LIBOR is 5%. The firm buys a call that matures in 40 days with a notional principal of \$5 million, 180 days in underlying ($D = 180$), and a strike rate of 4.5%. The call premium is \$8,000.

Calculate the effective annual rate of the loan if at expiration $\text{LIBOR} = 4\%$, and **calculate** if $\text{LIBOR} = 5\%$.

Answer:

First we compute the implied net amount to be borrowed after the cost of the call:

$$\$5,000,000 - \$8,000[1 + (0.05 + 0.03)(40 / 360)] = \$4,991,929$$

For $\text{LIBOR} = 0.04$ at expiration, the dollar cost is (the option is out-of-the-money):

$$\$5,000,000(0.07)(180 / 360) = \$175,000$$

The effective annual rate is:

$$(\$5,175,000 / \$4,991,929)^{(365/180)} - 1 = 0.0758$$

For $\text{LIBOR} = 0.05$, the call option is in-the-money:

$$\text{payoff} = (\$5,000,000)[\max(0, 0.05 - 0.045)(180 / 360)] = \$12,500$$

The dollar interest cost is effectively:

$$\$5,000,000(0.08)(180 / 360) - \$12,500 = \$187,500$$

The effective annual rate is:

$$(\$5,187,500 / \$4,991,929)^{(365/180)} - 1 = 0.0810$$

You should verify that the rate of 0.0810 is the highest possible rate by trying other values higher than $\text{LIBOR} = 4.5\%$.

Interest Rate Put

An interest rate put has a payoff to the owner when the reference rate, usually LIBOR, is *below* a certain strike rate at the maturity of the option:

$$\text{payoff} = (\text{NP})[\max(0, \text{strike rate} - \text{LIBOR})(D / 360)]$$

A lender can combine a long position in an interest rate put with a specific floating-rate loan to place a lower limit on the income to be earned on the position. The combination has many of the same basic mechanics as borrowing with an interest rate call. As in the case of the interest rate call, we compute the future value of the put premium, but we *add* it to the loan made by the lender because that represents the total outflow of cash from the lender at the time of the loan.

As in the case of the interest rate call, the payoff of the put places a limit on the effective dollar interest. In this case, the payoff is added to the interest received to ensure a *minimum* amount of revenue to the lender. To make our example easier to follow, we will look at the same loan examined in our last example, which was the second example of an interest rate call. Now we will look at it from the lender's point of view.

Example: Interest rate put

In 40 days, a bank plans to lend \$5 million for 180 days. The lending rate is LIBOR plus 300 basis points. The current LIBOR is 5%. The bank buys a put that matures in 40 days with a notional principal of \$5 million, 180 days in the underlying, and a strike rate of 4.5%. The put premium is \$5,000. **Calculate** the effective annual rate of the loan if at expiration LIBOR = 4%, and then calculate the rate if LIBOR = 5%.

Answer:

First we compute the total amount the bank pays out (lends) at time of the loan. This means computing the future value of the premium and adding it to the loan amount.

Loan amount plus future value of premium paid:

$$\$5,000,000 + \$5,000[1 + (0.05 + 0.03)(40 / 360)] = \$5,005,044$$

This amount is used for computing the effective interest rate earned on the outflow of cash at the beginning of the loan. The dollar interest earned by the bank will be based upon the prevailing rate applied to the loan and the payoff of the put. In this case, the expression is:

$$\begin{aligned} \text{effective interest earned} = \\ \$5,000,000(\text{LIBOR}_{\text{maturity}} + 0.03)(180 / 360) + (\text{put payoff}) \end{aligned}$$

The effective annualized rate on the loan is:

$$\text{EAR} = [(\$5,000,000 + \text{effective dollar interest earned}) / (\$5,005,044)]^{(365/180)} - 1$$

You can see where the lender gets hurt because both the principal returned and the interest earned are based upon the \$5 million, but the effective loan is \$5,005,044.

If $\text{LIBOR}_{\text{maturity}}$ equals 4%, the payoff of the put would be:

$$\text{payoff} = (\$5,000,000)[\max(0, 0.045 - 0.04)(180 / 360)] = \$12,500$$

The dollar interest earned is:

$$\$5,000,000(0.04 + 0.03)(180 / 360) = \$175,000$$

The effective interest rate is:

$$\text{EAR} = [(\$5,000,000 + \$175,000 + \$12,500) / (\$5,005,044)]^{(365/180)} - 1$$

$$\text{EAR} = [(\$5,187,500) / (\$5,005,044)]^{(365/180)} - 1$$

$$\text{EAR} = 0.07531 \text{ or } 7.531\%$$

While not asked, you might notice that in this case the put turned out to be desirable. Without the put the bank would have earned $\text{LIBOR} + 300 \text{ bp}$ or 7%.

If $\text{LIBOR}_{\text{maturity}} = 0.05$, the dollar interest earned is:

$$\$5,000,000[0.05 + 0.03](180 / 360) = \$200,000$$

$$\text{EAR} = [(\$5,200,000) / (\$5,005,044)]^{(365/180)} - 1$$

$$\text{EAR} = 0.08057 \text{ or } 8.057\%$$

Without the hedge, and $\text{LIBOR} = 5\% + 300 \text{ bp}$, the lender would have earned \$200,000 on only \$5 million for an effective rate of $0.08278 = [(\$5,200,000) / (\$5,000,000)]^{(365/180)} - 1$.

INTEREST RATE CAPS, FLOORS, AND COLLARS

LOS 37.d: Calculate the payoffs for a series of interest rate outcomes when a floating rate loan is combined with 1) an interest rate cap, 2) an interest rate floor, or 3) an interest rate collar.

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An interest rate cap is an agreement in which the cap seller agrees to make a payment to the cap buyer when the reference rate exceeds a predetermined level called the *cap strike* or *cap rate*. An interest rate floor is an agreement in which the seller agrees to pay the buyer when the reference rate falls below a predetermined interest rate called the *floor strike* or *floor rate*.

Caps and floors are over-the-counter contracts, so the two parties involved can tailor the agreement to suit their specific needs. Generally, the terms of a cap or floor agreement will include the:

- Reference rate (typically LIBOR).
- Cap or floor strike that sets the ceiling or floor.
- Length of the agreement.
- Reset frequency, which determines days in each settlement period, D_t .
- Notional principal (NP).

Interest Rate Caps

As an example, consider a cap with a cap rate of 8% on LIBOR for quarterly payments over the next year on \$1 million. Caps and floors are usually paid in arrears meaning that, in this case, the 3-month rate today would be used to calculate the payment three months from today. Because the first quarterly cash flow over the next year is already predetermined by the current rate, there is no time value for the first of the four options or *caplets*. One caplet expires after three months, one expires after six months, and one expires after nine months. The agent who is long the cap can only receive a payoff for any given caplet if LIBOR exceeds 8% on the specified date.

A cap can limit the upside of interest payments on a long-term floating-rate loan where interest payments are made over the life of the loan. That is the focus of our demonstration. The procedure is very similar to what we saw for interest rate options except that the payment in arrears makes it a little trickier. At each settlement date, the payoff is based upon the value of the reference rate, usually LIBOR, at the *beginning* of the period. However, the actual mathematics is the same for each caplet as it was for an interest rate call option. If the number of days since the last settlement period is 91, then for a caplet that expires on July 1, the payoff would be based upon LIBOR on April 1:

$$\text{payoff on July 1} = NP[\max(0, \text{LIBOR}_{\text{April 1}} - \text{strike rate})(91 / 360)]$$

If this was the first settlement, we might denote $D_1 = 91$. The subscript on D is necessary for caps and floors because the number of days for each settlement period usually changes over the course of each year. For a cap or floor that begins on January 1 and has settlement dates on April 1, July 1, October 1, and December 31, the corresponding numbers of days are 90, 91, 92, and 92. Despite this, we divide each D_t by 360 to determine the payoff.

Example: Interest rate cap

Suppose that a 1-year cap has a cap rate of 8% and a notional amount of \$100 million. The frequency of settlement is quarterly, and the reference rate is 3-month LIBOR. The contract begins on January 1. Determine the payoffs on April 1, July 1, October 1, and the following January 1 for the indicated LIBOR rates on those dates in the figure below.

LIBOR and Payoff Dates for an Interest Rate Cap

<i>Date</i>	<i>3-Month LIBOR</i>	<i>D_t</i>	<i>Payoff</i>
Jan. 1	7.7%	–	–
Apr. 1	8.0%	90	?
July 1	8.4%	91	?
Oct. 1	8.6%	92	?
Jan. 1 (year 2)	8.3%	92	?

Answer:

On January 1, there is no payoff and the cap's premium is paid. The payoff on April 1 would be based upon LIBOR = 7.7% and $D_1 = 90$:

$$\text{payoff on April 1} = \$100,000,000[\max(0, 0.077 - 0.08)(90 / 360)]$$

$$\text{payoff on April 1} = 0$$

The remaining payoffs are:

$$\text{payoff on July 1} = \$100,000,000[\max(0, 0.080 - 0.080)(91 / 360)] = \$0$$

$$\text{payoff on Oct. 1} = \$100,000,000[\max(0, 0.084 - 0.080)(92 / 360)] = \$102,222$$

$$\text{payoff on Jan. 1} = \$100,000,000[\max(0, 0.086 - 0.080)(92 / 360)] = \$153,333$$

When a long position in a cap is combined with a floating-rate loan, the payoffs can offset interest costs when the floating rate increases. Because caps trade over the counter, the terms of the cap are very flexible, so the cap buyer/borrower can align the settlements of the cap with the interest rate payments. This is seen in the following example.

Example: Interest rate cap and floating-rate loan

A borrower is combining a cap with a 2-year, floating-rate, \$20 million loan. The floating rate on the loan is LIBOR plus 200 bp to be paid semiannually. The loan is made on March 1 when LIBOR is 5%. The cap begins on that day also, and the strike rate is 6%. The loan payments and cap settlement dates are September 1 and March 1 over the next two years. LIBOR on the next three settlement dates are 6.1%, 6.4%, and 6.0%. Calculate the actual interest rate payments, settlements, and effective interest payments.

Answer:

A good first step is to determine the $D_{t,s}$ s; they are 184 and 181.

The payoffs on the caplets follow.

Year 1:

$$\text{payoff on Sept. 1} = \$20,000,000[\max(0, 0.050 - 0.060)(184 / 360)] = \$0$$

Year 2:

$$\text{payoff on March 1} = \$20,000,000[\max(0, 0.061 - 0.060)(181 / 360)] = \$10,056$$

$$\text{payoff on Sept. 1} = \$20,000,000[\max(0, 0.064 - 0.060)(184 / 360)] = \$40,889$$

Year 3:

$$\text{payoff on March 1} = \$20,000,000[\max(0, 0.060 - 0.060)(181 / 360)] = \$0$$

The actual interest payments on the loan are:

Year 1:

$$\text{payment on Sept. 1} = \$20,000,000[(0.050 + 0.020)(184 / 360)] = \$715,556$$

Year 2:

$$\text{payment on March 1} = \$20,000,000[(0.061 + 0.020)(181 / 360)] = \$814,500$$

$$\text{payment on Sept. 1} = \$20,000,000[(0.064 + 0.020)(184 / 360)] = \$858,667$$

Year 3:

$$\text{payment on March 1} = \$20,000,000[(0.060 + 0.020)(181 / 360)] = \$804,444$$

We subtract the payoff to find the effective interest payment:

Year 1:

$$\text{effective payment on Sept. 1} = \$715,556 - \$0 = \$715,556$$

Year 2:

$$\text{effective payment on March 1} = \$814,500 - \$10,056 = \$804,444$$

$$\text{effective payment on Sept. 1} = \$858,667 - \$40,889 = \$817,778$$

Year 3:

$$\text{effective payment on March 1} = \$804,444 - \$0 = \$804,444$$

You should note that the effective payment is the same for both March 1 settlements in the previous example, despite the fact that LIBOR was higher on the first settlement. The cap has set this upper limit. It has set an upper limit for September 1 settlements at \$817,778, which is higher because of the 184 versus 181 days in the settlement period.

Discussion

As you read examples of caps and floors, you should remember that they are OTC instruments. The counterparties can compose them any way they choose. They may choose to have irregular settlement periods, for example, or they may choose to base payoffs on a 365-day year rather than a 360-day year. Thus, if you see examples in other sources with slightly different inputs (e.g., 365 days versus 360 days), you should just go with it and focus on the mechanics of the procedure. Also remember that the premium of the cap (or floor) will depend upon the forward rates implied in the fixed income markets yield curves (i.e., the slope of the U.S. Treasury yield curve) combined with the cap buyer's own view of the direction and/or volatility of future interest rates.

LOS 37.d: Calculate the payoffs for a series of interest rate outcomes when a floating rate loan is combined with 1) an interest rate cap, 2) an interest rate floor, or 3) an interest rate collar. (continued)

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Interest Rate Floors

Having worked through the interest rate call examples, floors should seem relatively straightforward. The following example illustrates the mechanics of a floor and how a bank can combine it with a loan to fix a lower bound on the interest income to be received each period.

Example: Interest rate floor

For the next year, a bank wishes to use a floor to effectively place a lower limit on the interest it earns on a portfolio of floating-rate loans it has made. The value of the portfolio is \$80 million and payments are received quarterly based on LIBOR plus 300 basis points. Today is July 1, and the next payment dates are October 1, January 1, April 1, and July 1. Current LIBOR is 4.2%. The strike rate on the floor is 4.5%. The values of LIBOR on the first three settlement dates are 4.6%, 4.4%, and 4.6%. What are the actual interest rate payments (to the bank), settlements, and effective interest payments?

Answer:

We start by determining that $D_1 = 92$, $D_2 = 92$, $D_3 = 90$, and $D_4 = 91$. (These would probably be given on the exam.)

The payoffs on the floorlets are:

$$\begin{aligned}\text{Oct. 1} &= \$80,000,000[\max(0, 0.045 - 0.042)(92 / 360)] = \$61,333 \\ \text{Jan. 1} &= \$80,000,000[\max(0, 0.045 - 0.046)(92 / 360)] = \$0 \\ \text{April 1} &= \$80,000,000[\max(0, 0.045 - 0.044)(90 / 360)] = \$20,000 \\ \text{July 1} &= \$80,000,000[\max(0, 0.045 - 0.046)(91 / 360)] = \$0\end{aligned}$$

The interest payments are:

$$\begin{aligned}\text{Oct. 1} &= \$80,000,000[(0.042 + 0.030)(92 / 360)] = \$1,472,000 \\ \text{Jan. 1} &= \$80,000,000[(0.046 + 0.030)(92 / 360)] = \$1,553,778 \\ \text{April 1} &= \$80,000,000[(0.044 + 0.030)(90 / 360)] = \$1,480,000 \\ \text{July 1} &= \$80,000,000[(0.046 + 0.030)(91 / 360)] = \$1,536,889\end{aligned}$$

The effective payments are:

$$\begin{aligned}\text{Oct. 1} &= \$1,472,000 + \$61,333 = \$1,533,333 \\ \text{Jan. 1} &= \$1,553,778 + \$0 = \$1,553,778 \\ \text{April 1} &= \$1,480,000 + \$20,000 = \$1,500,000 \\ \text{July 1} &= \$1,536,889 + \$0 = \$1,536,889\end{aligned}$$

In this case, none of the effective payments is exactly equal because the floor was not in effect for both of the periods, which had the same number of days in settlement. The lowest payment the bank can expect is \$1,500,000 because that corresponds to the period with the fewest number of days, and the floor limits the payment to that amount for that period.

LOS 37.d: Calculate the payoffs for a series of interest rate outcomes when a floating rate loan is combined with 1) an interest rate cap, 2) an interest rate floor, or 3) an interest rate collar. (Continued)

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Interest Rate Collar

An interest rate collar is a combination of a cap and a floor where the agent is long in one position and short in the other. If the agent buys a 6% cap on LIBOR and sells a 3% floor on LIBOR, the agent will receive cash payments when LIBOR exceeds 6%, and the agent will make payments when LIBOR is below 3%. If LIBOR is between 3% and 6%, the agent neither receives nor pays.

This would be attractive to a bank that has among its liabilities large deposits with floating interest rates. When the rates start to rise, the bank's increasing costs can be offset by the payments from the collar. By selling the floor, the bank may have to make payments if the interest rates on the deposits fall too much, but the bank earned a premium for exposing itself to this risk. That premium offsets the cost of the cap. The overall position provides some certainty to the bank, because it essentially provides a predetermined range for the cost of funds.

A special interest rate collar occurs when the initial premiums on the cap and the floor are equal and offset each other. Suppose that the premium on a 4-year, 3% floor is equal to the premium on the 6% cap. The combination of the two would be called a *zero-cost collar* (a.k.a. a *zero-premium collar*). The motivation for zero-cost collars is that they are a way of providing interest rate protection without the cost of the premiums. Because this approach is so common, practitioners often use the term collar to refer to a zero-cost collar and only make a distinction when the premiums are not equal.

Example: Interest rate collar

Let's consider the bank in the previous example. It is now a year later, and the interest rate volatility has increased. As we might expect, this has made floors more expensive (remember Black-Scholes taught us that increased volatility increases the premium for all options). To offset the expense, the bank *sells* a cap and *buys* a floor.

For a 1-year maturity, it has found the optimal combination is to set a floor strike at 3.7% and a call strike at 5.1%. The premiums cancel (zero-cost collar). The value of the portfolio is now \$90 million and payments are received quarterly based on LIBOR plus 320 basis points. Today is July 1, and the next payment dates are October 1, January 1, April 1, and July 1. Current LIBOR is 4.5%. The values of LIBOR on the next three settlement dates are 6%, 4%, and 3%. Calculate the actual interest rate payments (to the bank), settlements, and effective interest payments.

Answer:

We recall that $D_1 = 92$, $D_2 = 92$, $D_3 = 90$, and $D_4 = 91$.

The payoffs on the derivatives are:

Floorlets:

$$\begin{aligned}\text{Oct. 1} &= \$90,000,000[\max(0, 0.037 - 0.045)(92 / 360)] = \$0 \\ \text{Jan. 1} &= \$90,000,000[\max(0, 0.037 - 0.060)(92 / 360)] = \$0 \\ \text{April 1} &= \$90,000,000[\max(0, 0.037 - 0.040)(90 / 360)] = \$0 \\ \text{July 1} &= \$90,000,000[\max(0, 0.037 - 0.030)(91 / 360)] = \$159,250\end{aligned}$$

Caplets:

$$\begin{aligned}\text{Oct. 1} &= \$90,000,000[\max(0, 0.045 - 0.051)(92 / 360)] = \$0 \\ \text{Jan. 1} &= \$90,000,000[\max(0, 0.060 - 0.051)(92 / 360)] = \$207,000 \\ \text{April 1} &= \$90,000,000[\max(0, 0.040 - 0.051)(90 / 360)] = \$0 \\ \text{July 1} &= \$90,000,000[\max(0, 0.030 - 0.051)(91 / 360)] = \$0\end{aligned}$$

The interest payments are:

$$\begin{aligned}\text{Oct. 1} &= \$90,000,000[(0.045 + 0.032)(92 / 360)] = \$1,771,000 \\ \text{Jan. 1} &= \$90,000,000[(0.060 + 0.032)(92 / 360)] = \$2,116,000 \\ \text{April 1} &= \$90,000,000[(0.040 + 0.032)(90 / 360)] = \$1,620,000 \\ \text{July 1} &= \$90,000,000[(0.030 + 0.032)(91 / 360)] = \$1,410,500\end{aligned}$$

The effective interest earned each period (not to be confused with effective annual rate) is:

$$\text{actual interest earned} + \text{floor payoff} - \text{cap payoff}$$

The following table illustrates how the payments and payoffs combine to give an effective rate for each period.

Cash Flows to an Interest Rate Collar

<i>Settlement</i>	<i>Actual Interest</i>	<i>Floor Payoffs</i>	<i>Cap Payoffs</i>	<i>Effective Interest</i>
October 1	\$1,771,000	0	0	\$1,771,000
January 1	\$2,116,000	0	-\$207,000	\$1,909,000
April 1	\$1,620,000	0	0	\$1,620,000
July 1	\$1,410,500	\$159,250	0	\$1,569,750

Discussion

Many variations of zero-cost collars can exist. For example, we can widen or tighten the spread by increasing the cap strike rate and lowering the floor strike rate. This will lower the cost of the cap as well as the income from selling the floor. In this case the buyer of

the collar is willing to take more interest rate risk, thus lowering the initial cost of the hedge. In some cases, it might even be convenient to have a different notional principal for the cap or floor to get the desired spread at zero cost.

If the notional principals for the cap and floor are \$1 million and \$2 million, respectively, the payoff will be twice as much for each basis point the reference rate falls below the floor strike rate than for each basis point the reference rate rises above the cap strike rate. Such a position is justifiable if the reference rate exhibits larger moves on the upside than on the downside (i.e., the reference rate is right-skewed).

For the Exam: Watch for a question in an item set where a bank uses an interest rate collar (i.e., sell a cap to purchase a floor) to manage the risk of falling rates on their floating-rate assets. In a morning case, be able to explain the construction (i.e., positions and costs) of the collar as well as explain whether the bank should use one, given current interest rates and expectations. Remember, even a zero-cost collar has potential costs in terms of lost profits. When you construct a collar, you protect against falling rates but you give up any profits associated with rising rates.

DELTA HEDGING

LOS 37.e: Explain why and how a dealer delta hedges an option position, why delta changes, and how the dealer adjusts to maintain the delta hedge.

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Delta hedging a derivative position means combining the option position with a position in the underlying asset to form a portfolio, whose value does not change in reaction to changes in the price of the underlying over a short period of time. The value of that portfolio should grow at the risk-free rate over time, as it is dynamically managed.

Dealers in derivatives stand ready to sell an option, such as a call, for which they earn a fee. If they sell the call *naked* (i.e., without any offsetting position), they would want to form a hedge to limit the risk. The dealer could hedge a short call by buying a call and effectively closing the position. The most popular activity, however, is to *delta hedge* a naked call by owning the underlying asset in an amount that will make the value of the short-call/long-asset portfolio immune to changes in the price of the underlying.

You may recall the covered-call strategy where an investor sells one call for each share of stock held. At expiration, the profit of a covered-call portfolio had an upside limit. Delta hedging differs because it focuses on the value of the call and how it changes prior to expiration. As it turns out, in delta hedging, the dealer can own fewer shares of stock (or units of the underlying asset) than the number of calls; that proportion is the delta. The symbol for delta is Δ , and it is a commonly used symbol for change.

Delta, for our purposes here, is the change in the price of an option for a 1-unit change in the price of the underlying security. For a call, a simple representation is:

$$\text{delta}_{\text{call}} = \frac{C_1 - C_0}{S_1 - S_0} = \frac{\Delta C}{\Delta S}$$

where:

$\text{delta}_{\text{call}}$ = delta of the call option

ΔC = change in the price of the call over a short time interval

ΔS = change in the price of the underlying stock over a short time interval

As the following examples will show, for a call: $0 \leq \text{delta} \leq 1$. (For long puts and short calls, delta fluctuates between 0 and -1 .) We will demonstrate why that property means that it takes fewer shares of stock to hedge a given number of calls. Also, we will see what makes delta increase or decrease in value.

Example: Calculating delta

During the last 20 minutes of trading, shares of a stock have risen from \$51.30 to \$52.05, and a given call option on the stock has risen from \$1.20 to \$1.60 in price. Calculate the delta of the call option.

Answer:

The call option delta can be estimated as:

$$\text{delta}_{\text{call}} = \frac{C_1 - C_0}{S_1 - S_0} = \frac{\Delta C}{\Delta S}$$

$$\text{delta}_{\text{call}} = \frac{\$1.60 - \$1.20}{\$52.05 - \$51.30} = \frac{\$0.40}{\$0.75} = 0.533$$

We can also calculate the change in option price given the option delta and the change in the security's price by rearranging the formula for the option delta as follows:

$$\text{delta}_{\text{call}} = \frac{\Delta C}{\Delta S} \Rightarrow \Delta C = \text{delta}_{\text{call}} \times \Delta S$$

The latter formula is usually of more concern to the dealer. This is because the dealer wants to estimate how the option price will change in response to a change in the price of the underlying. This is an estimation of the amount of risk in the position. The following is a simple demonstration.

Example: Using delta to estimate change in price

Call options on the stock in the previous example have a delta of 0.533. If the stock price rises by \$1.50, **calculate** the approximate change in the price of the option.

Answer:

We can expect the call option to rise by \$0.80:

$$\Delta C = 0.533 \times \$1.50 = \$0.80$$

For an investor or dealer who is short the call, this means an increased *liability* of \$0.80 per call.

The question is how a dealer who is short the call can hedge the risk of the position.

Example: Delta hedge

Call options on the stock in the previous example have a delta of 0.533. A dealer is short 100 contracts or 10,000 calls. **Calculate** the number of shares of the stock to delta hedge this portfolio.

Answer:

If the stock goes up by \$1, it means each call goes up by $\$1(0.533) = \$0.533$, which is an increased liability to the dealer, but the dealer can hedge each call with 0.533 shares of stock. That is, owning $10,000(0.533) = 5,330$ shares of stock will provide a delta-hedged call position. The reason is obvious: if the stock price goes up by \$1, then the value of the stock position goes up by \$5,330, while the liability of the short call will increase by the same amount and the two will immediately offset each other.

Unfortunately, it is not that easy for three very important reasons:

- Delta is only an *approximation* of the relative price changes of the stock and call and is less accurate for larger changes in stock price, ΔS .
- Delta changes as market conditions change, including changes in S .
- Delta changes over time without any other changes.



Professor's Note: The main challenge of delta hedging is to constantly adjust the hedge to accommodate changes in S and the passage of time. You must constantly rebalance the hedge for the new delta. On the exam you could be given a table with delta at various stock prices or dates and need to select the delta to use. You might have to calculate delta from option and underlying prices as in the previous example. You should also remember that if you are given Black-Scholes data the $N(d_1)$ term is the delta of the option. Finally remember that the absolute value of the call and put sum to 1.00. If you were given a call delta of .25 then the put with same expiration and strike delta is -.25.

Because we are hedged, the portfolio should be earning a risk-free rate of return based on a gain in value of the short call position and the fall in value of the stock.

Example: Delta hedge

The initial value of a call is \$1.40, which has a delta of 0.5739 as calculated in the Black-Scholes option pricing model and 30 days to maturity. A dealer sells 200 contracts or 20,000 calls. To delta hedge the position, the dealer purchases $20,000(0.5739) = 11,478$ shares of the stock at \$100/share. A day later, the price of the stock is the same with a new call price of \$1.39 and a delta of 0.5727. Calculate the initial value of the position and its value on the next day.

Answer:

Because the call is a liability (the dealer sold the call contracts), we subtract the value of the position from the value of the 11,478 shares:

$$\text{initial value of portfolio} = \$100(11,478) - \$1.40(20,000) = \$1,119,800$$

A day later we find:

$$\text{next-day value of portfolio} = \$100(11,478) - \$1.39(20,000) = \$1,120,000$$

The value of the portfolio has increased by 0.01785% ($200 / \$1,119,800$). This shows how the value of the portfolio will increase over time if the other inputs do not change. If precisely measured (i.e., without rounding), the rate of growth per day would be commensurate with the risk-free rate for one day at 6%: $e^{0.06/365} - 1 = 0.000164$, or 0.0164%.

As a point of reference, we will use the following value as our *benchmark*:

$$\begin{aligned} \text{value of portfolio tomorrow} &= (\text{value of portfolio today}) \times e^{r/365} \\ &= \$1,119,800(1.000164) = \$1,119,984 \end{aligned}$$

If you recall, with 29 days to maturity and other things equal, the delta will have decreased to 0.5727. Obviously, this means fewer shares of stock are required to delta hedge the 20,000 call options. The manager will now need only $20,000(0.5727) = 11,454$ shares. The manager should sell 24 ($11,478 - 11,454$) shares and invest the proceeds at the risk-free rate. Thus, the entire value of the original position will continue to grow at the risk-free rate.

Suppose the stock price changes on the next day (e.g., $S_{T=29 \text{ days}} = \$101$). We know that the delta will increase from the increase in price but it will tend to fall from the passage of time. From what we have seen so far, it will not be surprising that the price change will dominate and the value of delta will *increase* to 0.7040 as calculated in the Black-Scholes option pricing model.

Example: Adjusting a delta hedge

The initial value of a call is \$1.40, which has a delta of 0.5739 and 30 days to maturity. The price of the stock was $S_{T=30 \text{ days}} = \$100$. A dealer sells 200 contracts or 20,000 calls. To delta hedge the position, the dealer purchases 11,478 shares of the stock at \$100/share. A day later, the price of the stock is now $S_{T=29 \text{ days}} = \$101$ and all of the other inputs are the same, which gives $C = \$1.97$ and $\text{delta} = 0.7040$. Determine how the manager should adjust the hedge.

Answer:

Recall from the previous example that the original value of the portfolio at $T = 30$ days was \$1,119,800. For a perfectly hedged delta portfolio, at $T = 29$ days, the value of the portfolio will increase by a factor of $e^{0.06/365}$, where $0.06 / 365$ represents a day's worth of interest. The manager must purchase:

$$\begin{aligned} \text{number of shares} &= (\text{number of calls})(\text{new delta} - \text{old delta}) \\ &= (20,000)(0.7040 - 0.5739) = 2,602 \text{ new shares} \end{aligned}$$

To purchase the new shares, the manager will *borrow at the risk-free rate*. Borrowing and investing the money in the delta-hedged portfolio will not change the value of the net position, which will continue to grow at the risk-free rate.

In summary, the challenge to the delta-hedging manager is the need to continually rebalance to maintain the hedge. Done correctly, the strategy will earn a risk-free rate of return over time for the delta-hedged portfolio.

Professor's Note: You may be a bit confused about the following discrepancy. Recall from the previous example that the original value of the portfolio at $T = 30$ days was \$1,119,800.

A day later, using the call value provided, we find:

$$\text{next-day value of portfolio} = \$101(11,478) - \$1.97(20,000) = \$1,119,878$$



Using our rounded values, we see that the portfolio has increased by \$78, which is less than the \$184 ($= \$1,119,984 - \$1,119,800$) increase predicted by our benchmark based upon the risk-free rate. The rounding process makes precise demonstrations almost impossible.

The main purpose of the LOS is to help you understand that a delta-hedged portfolio will grow at the risk-free rate over time, and the manager should borrow or invest funds at the risk-free rate to adjust the position in the underlying asset. Thus, do not let the aforementioned discrepancy get in the way.

THE SECOND-ORDER GAMMA EFFECT

LOS 37.f: Interpret the gamma of a delta-hedged portfolio and explain how gamma changes as in-the-money and out-of-the-money options move toward expiration.

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Gamma measures the change in the value of delta with a change in the value of the underlying stock. Expressing the relationship as an equation:

$$\text{gamma} = \frac{\text{change in the value of delta}}{\text{change in the price of the underlying}} = \frac{\Delta\text{delta}}{\Delta\text{stock}}$$



Professor's Note: You might have heard gamma referred to as the second order gamma effect. This is because gamma is the second derivative of the option price relative to the underlying stock price. It is the rate of change in delta, which can vary significantly.

An important relationship exists between the value of gamma and the risk of the delta-hedged position. If delta were perfectly linear, gamma would equal 0, and one could perfectly delta hedge an option position. The return to the delta hedge would be the risk-free rate.

Think of it this way: if gamma were zero, delta must be constant because it would be the slope of a straight line. That means the price of the option will move by the same amount for a given change in the price of the underlying stock, either negative or positive. The manager would never have to adjust the delta hedge.

Unfortunately, we know that the change in the value of an option is not linear (i.e., the value of delta changes as the price of the underlying changes). Therefore, gamma must be non-zero and there must be risk associated with the delta hedge. In fact, the greater the value of gamma, the more risk in the position (i.e., more variability in the value of the option).

Remember the relationship of delta to the price of the underlying relative to the option's strike price (i.e., *moneyness* of the option). If a call option is in-the-money, its delta will generally be above 0.5, and as it approaches expiration, its delta approaches 1.0. Likewise, if the option is out-of-the-money, its delta will usually be below 0.5, and as it approaches expiration, its delta falls to zero.

As an at- or near-the-money option approaches expiration, its delta will tend to move quickly to either one or zero, depending on the direction of the stock price movement. Thus, gamma of an at-the-money option is greatest near the expiration date. When option values are subject to large changes (i.e., when gamma is large), the position faces the most risk, and a delta hedger is more likely to gamma hedge. The hedge entails combining the underlying stock position with two options positions in such a manner that both delta and gamma are equal to zero.

For the Exam: The exact two-option strategy is not discussed in the curriculum, so you will not have to describe it on the exam. Just remember that the risk of a delta hedge is greatest when gamma is large, so delta hedgers will take a position in two options, such that delta and gamma are equal to zero.

KEY CONCEPTS

LOS 37.a

An investor creates a *covered call* position by buying the underlying security and selling a call option. Covered call writing strategies are used to generate additional portfolio income when the investor believes that the underlying stock price will remain unchanged over the short term.

A *protective put* (also called *portfolio insurance* or a *hedged portfolio*) is constructed by holding a long position in the underlying security and buying a put option. You can use a protective put to limit the downside risk at the cost of the put premium, P_0 .

The purchase of the put provides a lower limit to the position at a cost of lowering the possible profit (i.e., the gain is reduced by the cost of the *insurance*). It is an ideal strategy for an investor who thinks the stock may go down in the near future, yet the investor wants to preserve upside potential.

LOS 37.b

There are many strategies that combine calls, puts, and the underlying asset.

- A bull spread strategy consists of a long call and a short call. The short call has a higher exercise price, and its premium subsidizes the long call. It offers gains if the underlying asset's price goes up, but the upside is limited.
- A bear spread strategy is the opposite side of a bull spread. It offers a limited upside gain if the underlying asset's price declines.
- A butterfly spread consists of two long and two short call positions. It offers a return, with a limited upside if the underlying asset price does not move very much.
- A collar strategy is simply a covered call and protective put combined to limit the down and upside value of the position.
- A long straddle is a long call and long put with the same exercise price. The greater the move in the stock price, the greater the payoff from a straddle.
- A box spread strategy combines a long put and a short put with a long call and a short call to produce a guaranteed return. That return should be the risk-free rate.

LOS 37.c

A long interest rate call can limit the effective interest paid on a floating-rate loan for a given period. The call pays the call holder when rates rise above the strike rate, and that offsets the increased cost of the floating-rate loan. The effective interest paid on the loan/call position is the actual interest minus the call payoff divided by the loan amount minus the call premium (this ratio would be annualized).

$$\text{interest rate call payoff} = (NP)[\max(0, \text{LIBOR} - \text{strike rate})](D / 360)$$

A long interest rate put can place a lower limit on the effective interest to be received by a lender of a floating-rate loan for a given period. It pays the put holder when rates decrease below the strike rate, and that offsets the decreased income from the floating-rate loan. The effective interest received with the loan/put position is the actual interest plus the put payoff divided by the loan amount plus the put premium (this ratio would be annualized).

$$\text{interest rate put payoff} = (NP)[\max(0, \text{strike rate} - \text{LIBOR})(D / 360)]$$

LOS 37.d

An interest rate cap is a series of interest rate calls with the same strike rate but different expiration dates. Settlements are at the end of each period but are based on rates at the beginning of each period.

An interest rate floor is a series of interest rate puts with the same strike rate but different expiration dates. As with the cap, settlements are at the end of each period based on rates at the beginning of each period.

An interest rate collar is a combination of cap and floor where the investor is long one and short the other. A short cap and long floor would be of use to a lender of floating-rate loans. The collar will guarantee a range of income for the total position to the lender. A long cap and short floor will guarantee a floating-rate borrower a range of interest costs on the loan.

LOS 37.e

Delta hedging generally refers to immunizing the value of an option position from changes in the value of the underlying asset. One such procedure is to immunize a naked call position with a long position in the underlying asset. Correctly done, over time this portfolio should increase in value at the risk-free rate. The problem is that the correct amount of shares to hold for the delta hedge will change. Over time, delta will change and the manager should periodically adjust the asset's position and invest in or borrow at the risk-free asset to keep the hedge.

Delta is the change in the price of an option for a 1-unit change in the price of the underlying security.

$$\text{delta}_{\text{call}} = \frac{C_1 - C_0}{S_1 - S_0} = \frac{\Delta C}{\Delta S}$$

where:

$\text{delta}_{\text{call}}$ = delta of the call option

ΔC = change in the price of the call over a short time interval

ΔS = change in the price of the underlying stock over a short time interval

For a long call: $0 \leq \text{delta} \leq 1$. For long puts and short calls, delta fluctuates between 0 and -1.

LOS 37.f

$$\text{gamma} = \frac{\text{change in the value of delta}}{\text{change in the price of the underlying}} = \frac{\Delta \text{delta}}{\Delta \text{stock}}$$

As an at- or near-the-money option approaches expiration, its delta will tend to move quickly to either one or zero, depending on the direction of the stock price movement. Thus, gamma of an at-the-money option is greatest near the expiration date. When option values are subject to large changes (i.e., when gamma is large), the position faces the most risk, and a delta hedger is more likely to gamma hedge. The hedge entails combining the underlying stock position with two options positions in such a manner that both delta and gamma are equal to zero.

CONCEPT CHECKERS

1. The holder of a long straddle *most likely* will have a net loss if the asset's price:
 - A. stays the same.
 - B. moves up.
 - C. moves down.
2. A butterfly spread consists of:
 - A. two put option contracts.
 - B. four call option contracts.
 - C. two call options and two put options.
3. For hedging risk, owning an interest rate put would *most likely* be useful for a:
 - A. variable-rate borrower.
 - B. fixed-rate lender.
 - C. variable-rate lender.
4. A cap contract has a notional principle of \$5 million, a strike rate of 5%, and an annual frequency of settlement. If the reference rate is 6% for a given settlement date, what is the payoff to the agent long the cap for that period?
 - A. \$25,000.
 - B. \$50,000.
 - C. \$100,000.

Use the following information to answer Questions 5, 6, and 7.

An option dealer holds 1,000 shares of a stock. The stock is currently trading at \$70 per share. At-the-money call options have a delta of 0.60.

5. Which of the following indicates the number of call options the dealer must have sold if the shares were purchased to create a delta hedge?
 - A. 1,000 options.
 - B. 1,400 options.
 - C. 1,667 options.
6. If the delta associated with the call option changes from 0.60 to 0.70, which of the following would be appropriate to maintain a delta-neutral portfolio?
 - A. Sell an additional 100 call options.
 - B. Purchase 100 shares of the stock.
 - C. Purchase 167 shares of the stock.
7. If the value of the stock falls \$3 and the value of the call option falls \$1.25, what is the delta of the call option?
 - A. 0.4167.
 - B. 0.2400.
 - C. 0.3750.

8. In 60 days, a bank plans to lend \$10 million for 90 days. The lending rate is LIBOR plus 200 basis points. The current LIBOR is 4%. The bank buys a put that matures in 60 days with a notional principal of \$10 million, 90 days in underlying, and a strike rate of 5%. The put premium is \$2,000. Calculate the effective annual rate of the loan if at expiration the LIBOR = 4.5%, and if the LIBOR = 6.5%.
9. A bank composes a 2-year, zero-cost collar for a \$20 million portfolio of floating-rate loans by buying the floor and selling the cap. The floor strike is 2.5%, the cap strike is 4.7%, and the reference rate is LIBOR. The interest payments are LIBOR plus 240 basis points. The collar's semiannual settlement dates exactly match the dates when the floating-rate payments are made: August 1 and February 1 over the next two years. Today is August 1. Current LIBOR is 4.1%. The values of LIBOR on the next three settlement dates are 2.4%, 5%, and 5%. Calculate the actual interest rate payments (to the bank), settlements, and effective interest payments.

ANSWERS – CONCEPT CHECKERS

1. A If the asset's price is between the put and call breakeven points, the long straddle produces a net loss.
2. B A butterfly spread consists of two short call positions with the same exercise price and a long position in two calls, one with a higher exercise price and one with a lower exercise price.
3. C The put pays the floor holder when interest rates fall, so they would hedge the risk of a variable rate.
4. B $\text{payoff} = \$50,000 = (\$5,000,000)(0.06 - 0.05)(1)$
5. C First, compute the number of calls to sell per share of stock that we hold long. $1 / 0.6 = 1.667 = \text{number of calls to short per share}$. Hence, to create the appropriate delta-neutral hedge for 1,000 shares, sell 1,667 calls.
6. C The original position was 1,000 shares and 1,667 calls. If the delta increases to 0.7, the number of required additional shares would be $167 = 1,667(0.7 - 0.6)$. Alternatively, you can calculate the new required number of shares at the new delta value. This would be $1,667(0.70) \cong 1,167$. Because the dealer currently holds 1,000 shares, she would purchase another 167 to maintain the delta hedge.
7. A $\text{Delta} = (\text{change in call}) / (\text{change in asset})$; thus, $\text{delta} = 1.25 / 3 = 0.4167$.
8. First, we compute the effective amount the bank parts with or lends at time of the loan. This means computing the future value of the premium:

$$\text{future value of premium} = \$2,020 = \$2,000[1 + (0.04 + 0.02)(60 / 360)]$$

Thus, the cash outflow at the loan's inception is \$10,002,020. At the given LIBOR rates of 4.5% and 6.5%, the put's payoffs are:

$$\begin{aligned} \text{LIBOR} = 4.5\%: \text{payoff} &= \$12,500 = \$10,000,000[\max(0, 0.050 - 0.045)(90 / 360)] \\ \text{LIBOR} = 6.5\%: \text{payoff} &= \$0 = \$10,000,000[\max(0, 0.050 - 0.065)(90 / 360)] \end{aligned}$$

The interest income earned is:

$$\begin{aligned} \text{LIBOR} = 4.5\%: \text{int. income} &= \$162,500 = \$10,000,000 \times (0.045 + 0.020)(90 / 360) \\ \text{LIBOR} = 6.5\%: \text{int. income} &= \$212,500 = \$10,000,000 \times (0.065 + 0.020)(90 / 360) \end{aligned}$$

The effective rate earned is:

$$\begin{aligned} \text{LIBOR} = 4.5\%: \\ \text{EAR} &= [(\$10,000,000 + \$162,500 + \$12,500) / (\$10,002,020)]^{(365 / 90)} - 1 \\ \text{EAR} &= [\$10,175,000 / (\$10,002,020)]^{(365 / 90)} - 1 \\ \text{EAR} &= 0.0720 = 7.2\% \end{aligned}$$

$$\begin{aligned} \text{LIBOR} = 6.5\%: \\ \text{EAR} &= [(\$10,000,000 + \$212,500 + \$0) / (\$10,002,020)]^{(365 / 90)} - 1 \\ \text{EAR} &= [\$10,212,500 / (\$10,002,020)]^{(365 / 90)} - 1 \\ \text{EAR} &= 0.0881 = 8.81\% \end{aligned}$$

9. In this case $D_t = 184$ and 181 for February 1 and August 1, respectively. The payoffs on the derivatives are:

Floorlets:

Year 1

$$\begin{aligned}\text{payoff on Feb. 1} &= \$0 = \$20,000,000[\max(0, 0.025 - 0.041)(184 / 360)] \\ \text{payoff on Aug. 1} &= \$10,056 = \$20,000,000[\max(0, 0.025 - 0.024)(181 / 360)]\end{aligned}$$

Year 2

$$\begin{aligned}\text{payoff on Feb. 1} &= \$0 = \$20,000,000[\max(0, 0.025 - 0.050)(184 / 360)] \\ \text{payoff on Aug. 1} &= \$0 = \$20,000,000[\max(0, 0.025 - 0.050)(181 / 360)]\end{aligned}$$

Caplets:

Year 1

$$\begin{aligned}\text{payoff on Feb. 1} &= \$0 = \$20,000,000[\max(0, 0.041 - 0.047)(184 / 360)] \\ \text{payoff on Aug. 1} &= \$0 = \$20,000,000[\max(0, 0.024 - 0.047)(181 / 360)]\end{aligned}$$

Year 2

$$\begin{aligned}\text{payoff on Feb. 1} &= \$30,667 = \$20,000,000[\max(0, 0.050 - 0.047)(184 / 360)] \\ \text{payoff on Aug. 1} &= \$30,167 = \$20,000,000[\max(0, 0.050 - 0.047)(181 / 360)]\end{aligned}$$

The interest payments are:

$$\begin{aligned}\text{pmt. on Feb. 1} &= \$664,444 = \$20,000,000(0.041 + 0.024)(184 / 360) \\ \text{pmt. on Aug. 1} &= \$482,667 = \$20,000,000(0.024 + 0.024)(181 / 360) \\ \text{pmt. on Feb. 1} &= \$756,444 = \$20,000,000(0.050 + 0.024)(184 / 360) \\ \text{pmt. on Aug. 1} &= \$744,111 = \$20,000,000(0.050 + 0.024)(181 / 360)\end{aligned}$$

The following table illustrates how the payments and payoffs combine to give an effective rate for each period.

<i>Settlement</i>	<i>Year</i>	<i>Actual Interest</i>	<i>Floor Payoffs</i>	<i>Cap Payoffs</i>	<i>Effective Interest</i>
Feb. 1	1	\$664,444	0	0	\$664,444
Aug. 1	1	\$482,667	\$10,056	0	\$492,723
Feb. 1	2	\$756,444	0	-\$30,667	\$725,777
Aug. 1	2	\$744,111	0	-\$30,167	\$713,944

RISK MANAGEMENT APPLICATIONS OF SWAP STRATEGIES

Study Session 15

EXAM FOCUS

This topic review goes rather deeply into swaps and swaptions. The material can be rather complex, so go slowly and make sure you understand each section before progressing to the next. Be ready to solve calculations as well as answer conceptual questions. I would also expect you to see situations where you will have to select which alternative would be the most appropriate for a given scenario.

USING SWAPS TO CONVERT LOANS FROM FIXED (FLOATING) TO FLOATING (FIXED)

LOS 38.a: Demonstrate how an interest rate swap can be used to convert a floating-rate (fixed-rate) loan to a fixed-rate (floating-rate) loan.

CFA® Program Curriculum, Volume 5, page 449

The most common interest rate swap is the *plain vanilla* interest rate swap. In this swap, Company X agrees to pay Company Y a periodic fixed rate on a notional principal over the tenor of the swap. In return, Company Y agrees to pay Company X a periodic floating rate on the same notional principal. Payments are in the same currency, so only the net payment is exchanged.

Most interest rate swaps use the London Interbank Offered Rate (LIBOR) as the reference rate for the floating leg of the swap. Finally, because the payments are based in the same currency, there is no need for the exchange of principal at the inception of the swap. This is why it is called *notional* principal.

Example: Vanilla swap

Companies X and Y enter into a 1-year plain vanilla interest rate swap. The swap cash flows are exchanged quarterly, and the reference rate is 3-month LIBOR. The swap fixed rate is 3.6% and the notional principal is \$100 million.

Because Company X has a \$100 million variable rate loan on which to make payments, X will enter the swap as the pay-fixed party. Because Y has a \$100 million fixed-rate loan on which to make payments, Y will take the pay-floating side of the swap.

Compute the cash flows for the two firms.

Date	Days in Period	Swap Cash Flows			
		LIBOR	Floating Cash Flow	Fixed Cash Flow	Net Cash Flow to X
Jan. 1		3.0%			
April 1	90	3.5%	\$750,000	\$900,000	–\$150,000
July 1	91	4.0%	\$884,722	\$910,000	–\$25,278
Oct. 1	92	4.5%	\$1,022,222	\$920,000	\$102,222
Jan. 1 (year 2)	92	5.0%	\$1,150,000	\$920,000	\$230,000

Answer:

For the Exam: You will notice that an interest rate on January 1 (year 2) is given in the table, even though it is not used to calculate swap payments. It is quite likely that this will be the case on the exam, too. In settling swaps, you need to remember to use the interest rate at the beginning of the period.

The first cash flow takes place on April 1 and *uses LIBOR on January 1*; thus, at the beginning of each period, the payments for the end of the period are known. The cash flows on April 1 are:

$$\text{floating} = \$100 \text{ million} (0.03) \left(\frac{90}{360} \right) = \$750,000 \text{ (obligation of Company Y)}$$

$$\text{fixed} = \$100 \text{ million} (0.036) \left(\frac{90}{360} \right) = \$900,000 \text{ (obligation of Company X)}$$

(90/360) corresponds to the number of days in the first period and follows the usual convention of dividing by 360. The net is a payment for Company X of \$150,000 to Company Y. If Company X had a \$100,000,000 floating-rate loan outstanding, where the floating rate was *LIBOR plus 200 basis points*, its payment on the swap would increase its interest cost for the period:

$$\text{X's loan payment on April 1} = \$100,000,000 (0.03 + 0.02) \left(\frac{90}{360} \right) = \$1,250,000$$

$$\text{X's total cost with the swap on April 1} = \$1,250,000 + \$150,000 = \$1,400,000$$

The swap increased the total outflow for X in the first period, and for the second period we find:

$$\text{X's loan payment on July 1} = \$100,000,000(0.035 + 0.02)\left(\frac{91}{360}\right) = \$1,390,278$$

$$\text{X's total cost with the swap on July 1} = \$1,390,278 + \$25,278 = \$1,415,556$$

You will note that these payments correspond to payments made on a loan with quarterly fixed 5.6% ($0.036 + 0.020$) payments as shown here:

$$\text{payments at 5.6\% (90-day period)} = \$100,000,000(0.056)\left(\frac{90}{360}\right) = \$1,400,000$$

$$\text{payments at 5.6\% (91-day period)} = \$100,000,000(0.056)\left(\frac{91}{360}\right) = \$1,415,556$$

Company X has effectively converted its floating-rate obligation to a fixed rate. The formula for Company X's (the pay-fixed party) net payments is fairly straightforward:

$$\text{total payment}_{\text{pay-fixed}} = \text{loan payment} - \text{swap receipt} + \text{swap payment}$$

where:

$$\text{loan payment} = \$100,000,000(\text{LIBOR} + 0.02)\frac{D_t}{360}$$

$$\text{swap receipt} = \$100,000,000(\text{LIBOR})\frac{D_t}{360}$$

$$\text{swap payment} = \$100,000,000(0.036)\frac{D_t}{360}$$

so:

$$\text{total payment} = \$100,000,000(\text{LIBOR} + 0.02 - \text{LIBOR} + 0.036)\frac{D_t}{360}$$

and:

$$\text{net payment} = \$100,000,000(0.036 + 0.02)\frac{D_t}{360}$$

or in general:

$$\text{net payment}_{\text{pay-fixed}} = \text{NP}(\text{swap fixed rate} \pm \text{loan spread})\frac{D_t}{360}$$

where:

NP = notional principal

D_t = days since last payment

This assumes, of course, that the settlement days of the swap correspond to the interest payments of the loan, and the floating rates are both tied to the same reference rate (e.g., LIBOR in this case).

It should not be surprising that if Company Y is a borrower at a fixed rate, it will now effectively pay a floating rate. A borrower at a fixed rate who enters into the swap as a floating-rate payer will have interest costs each period equal to:

$$\text{total payment}_{\text{pay-floating}} = \text{loan payment} - \text{swap receipt} + \text{swap payment}$$

where:

$$\text{loan payment} = \$100,000,000(0.06)\frac{D_t}{360}$$

$$\text{swap receipt} = \$100,000,000(0.036)\frac{D_t}{360}$$

$$\text{swap payment} = \$100,000,000(\text{LIBOR})\frac{D_t}{360}$$

so:

$$\text{total payment} = \$100,000,000(0.060 - 0.036 + \text{LIBOR})\frac{D_t}{360}$$

and:

$$\text{net payment} = \$100,000,000(\text{LIBOR} + 0.024)\frac{D_t}{360}$$

or in general:

$$\text{net payment}_{\text{pay-floating}} = \text{NP}(\text{loan rate} - \text{swap rate} + \text{LIBOR})\frac{D_t}{360}$$

where:

NP = notional principal

D_t = days since last payment

We can net Company Y's 6% loan payments with the swap payments. For the periods April 1 and July 1, the total interest cost from the loan and the swap would be:

$$\begin{aligned} \text{Y's net cost with swap on April 1} &= \text{loan payment} + \text{swap floating payment} \\ &\quad - \text{swap fixed receipt} \end{aligned}$$

$$= \$100,000,000(0.06)\frac{90}{360} + \$100,000,000(0.03)\frac{90}{360} - \$100,000,000(0.036)\frac{90}{360}$$

$$= \$1,500,000 + \$750,000 - \$900,000 = \$1,350,000$$

or:

$$\text{Y's net cost with swap on April 1} = \text{NP}(\text{loan rate} - \text{swap rate} + \text{LIBOR})\frac{D_t}{360}$$

$$= \$100,000,000(0.060 - 0.036 + 0.030)\left(\frac{90}{360}\right) = \$1,350,000$$

and:

$$\text{Y's net cost with swap on July 1} = \text{NP}(\text{loan rate} - \text{swap rate} + \text{LIBOR})\frac{D_t}{360}$$

$$= \$100,000,000(0.060 - 0.036 + 0.035)\left(\frac{91}{360}\right) = \$1,491,389$$

Company Y has converted a fixed-rate liability to a floating-rate liability at a set spread above LIBOR (i.e., $0.060 - 0.036 = 240$ basis points in this case).

Example: Swap payments

Verify that the last two net payments (interest cost and swap cash flow) of Company X in the previous example will be equal. Explain why.

Answer:

Cash Flows on a Plain Vanilla Swap on \$100 Million Notional Principal

Date	Days in Period	Swap Cash Flows			
		LIBOR	Floating Cash Flow	Fixed Cash Flow	Net Cash Flow to X
Jan. 1		3.0%			
April 1	90	3.5%	\$750,000	\$900,000	-\$150,000
July 1	91	4.0%	\$884,722	\$910,000	-\$25,278
Oct. 1	92	4.5%	\$1,022,222	\$920,000	\$102,222
Jan. 1 (year 2)	92	5.0%	\$1,150,000	\$920,000	\$230,000

We see from the table above (reproduced for your convenience) that Company X will have an inflow from the swap on the last two dates, which will lower

$$X's \text{ interest cost on Oct. 1} = \$100,000,000(0.04 + 0.02)\left(\frac{92}{360}\right) = \$1,533,333$$

$$X's \text{ total cost with the swap on Oct. 1} = \$1,533,333 - \$102,222 = \$1,431,111$$

The swap decreased the outflow for the third period as it did for the last period:

$$X's \text{ interest costs on Jan. 1} = \$100,000,000(0.045 + 0.020)\left(\frac{92}{360}\right) = \$1,661,111$$

$$X's \text{ total cost with the swap on Jan. 1} = \$1,661,111 - \$230,000 = \$1,431,111$$



Professor's Note: The last two net payments had to be the same (\$1,431,111) because LIBOR was greater than the fixed rate and the last two periods had the same number of days: $D_3 = D_4 = 92$.

Example: Effective swap rate

Verify that the 6% Company Y pays on its loan, plus the cash flow from the swap, gives an effective payment of LIBOR + 240 basis points each period.

Answer:

Using the data from the table, the cash flows to X are payments from Y. Although paying a fixed rate of 6%, the periodic payments made by Y on its actual loan will vary slightly because of the differences in D_t . The interest payments on the loan plus the swap cash flows are:

$$\text{total cost April 1} = \$100,000,000(0.06)\left(\frac{90}{360}\right) - \$150,000 = \$1,350,000$$

$$\text{total cost July 1} = \$100,000,000(0.06)\left(\frac{91}{360}\right) - \$25,278 = \$1,491,389$$

$$\text{total cost Oct. 1} = \$100,000,000(0.06)\left(\frac{92}{360}\right) + \$102,222 = \$1,635,556$$

$$\text{total cost Jan. 1} = \$100,000,000(0.06)\left(\frac{92}{360}\right) + \$230,000 = \$1,763,333$$

To compute the payments made on a floating-rate loan where the interest rate is LIBOR + 240 basis points, we can recall our formula:

$$\text{total interest cost} = NP(\text{loan rate} - \text{swap rate} + \text{LIBOR})\left(\frac{D_t}{360}\right)$$

$$\text{total cost April 1} = \$100,000,000(0.06 - 0.036 + 0.030)\left(\frac{90}{360}\right) = \$1,350,000$$

$$\text{total cost July 1} = \$100,000,000(0.06 - 0.036 + 0.035)\left(\frac{91}{360}\right) = \$1,491,389$$

$$\text{total cost Oct. 1} = \$100,000,000(0.06 - 0.036 + 0.040)\left(\frac{92}{360}\right) = \$1,635,556$$

$$\text{total cost Jan. 1} = \$100,000,000(0.06 - 0.036 + 0.045)\left(\frac{92}{360}\right) = \$1,763,333$$

The two sets of cash flows are the same: a floating rate based on LIBOR plus the difference in the fixed and swap rate.



Professor's Note: Floating-rate loans are usually referred to as floating-rate notes (FRN). We say that a borrower, who has borrowed at a floating rate, has issued an FRN. This term shows up a lot in discussions and examples concerning swaps.

DURATION OF AN INTEREST RATE SWAP

LOS 38.b: Calculate and interpret the duration of an interest rate swap.

CFA® Program Curriculum, Volume 5, page 451

The duration properties of swaps are another reason for their popularity. Each counterparty in a swap is essentially either of the following:

- Long a fixed cash flow and short a floating cash flow.
- Short a fixed cash flow and long a floating cash flow.

You should recall that duration is the sensitivity of an asset's price to changes in a relevant interest rate. Here are two important points with respect to fixed and floating-rate instruments:

1. For fixed-rate instruments, duration will be higher because the change in interest rates will change the present value of the fixed cash flows.
2. For floating-rate instruments, duration is close to zero because the future cash flows vary with interest rates, and the present value is fairly stable with respect to changes in interest rates.

A *floating-rate* instrument can have a non-zero duration if its next cash flow has been set, which is the case with swaps. The convention is to treat the duration of the floating rate side of the swap as being half the reset period. For example, for a 6-month reset, the duration would be taken to be 0.25, for a quarterly reset it would be taken to be 0.125, etc.

Because we know that the duration of a zero-coupon bond is its maturity, the duration of the floating payments where the next payment is known will be the time to the next payment. At inception or just after a settlement for a *quarterly* reset swap, the duration of the floating payments is 0.25; for a *semiannual* reset swap, the duration is 0.5; et cetera. Just before the payment is due, however, the duration is 0.0. Hence, the *average* duration of a floating instrument over the reset period is one-half the length of its settlement periods.

For a pay-floating counterparty in a swap, the duration can be expressed as:

$$D_{\text{pay floating}} = D_{\text{fixed}} - D_{\text{floating}} > 0$$

Because the floating-rate payor receives fixed cash flows, taking the receive-fixed/pay-floating position in a swap increases the dollar duration of a fixed-income portfolio. The modified duration of the portfolio will move an amount determined by (1) the relative values of the notional principal of the swap and the portfolio's value and (2) relative values of the modified duration of the swap and that of the portfolio.



Professor's Note: Turning this statement around, the receive-floating position experiences a fall in the fixed-income portfolio duration, as would be expected, because being the pay-fixed party is like taking on a new fixed-rate liability.

Example: Pay-floating swap duration

At the inception of a 2-year swap, the duration of the fixed payments is 1.1, and the duration of the floating payments is 0.25. What is the duration of the swap to the pay-floating party to the swap?

Answer:

The duration of the swap is $1.1 - 0.25 = 0.85$.

The sign of the duration of the swap depends upon which side of the swap you're on. The pay-fixed side of the swap has effectively added a fixed-rate liability, so the duration for the swap in this example is -0.85 , which reduces the duration of the overall portfolio. The receive-fixed side of the portfolio, however, has effectively added a fixed-rate asset, so the duration of this same swap is $+0.85$. In other words, the duration is determined primarily by the fixed side of the swap; that is, whether it is being received (like receipts on a fixed-rate asset) or paid (like the payments on a fixed-rate liability).

For the Exam: Your understanding of the fixed income section, particularly duration, will be beneficial to your studies of swap strategies. Swaps can be used to alter the duration of a fixed-income portfolio to produce risk/return characteristics that are more in-line with expectations (e.g., add a call feature to outstanding bonds). Credit derivatives, such as credit default swaps, are another example of using swap strategies with a fixed-income portfolio. Equity portfolio managers can also use swaps to alter the risk/return characteristics of their stock portfolios. The bottom line is that you should be ready for swaps to show up in numerous places on the exam.

MARKET VALUE RISK AND CASH FLOW RISK

LOS 38.c: Explain the effect of an interest rate swap on an entity's cash flow risk.

CFA® Program Curriculum, Volume 5, page 452

It is common to refer to converting a floating-rate liability to fixed-rate as a hedge. In the sense that it reduces cash flow risk, it is a hedge. However, it is essentially converting highly visible cash flow risk into less visible market value risk.

Cash flow risk is reduced by entering the swap because the uncertain future floating-rate payments on the liability are essentially converted to fixed payments that can be more easily planned for and budgeted, resulting in a reduction in cash flow risk. However, the low duration of the floating-rate liability is now converted to the higher duration of a fixed-rate liability. The liability market value will now fluctuate more as interest rates change. For example, if interest rates fall, the liability will rise in market value, creating a corresponding decline in the firm's theoretical market value of equity.

Some argue that these changes in market value are unrealized, which is true. They are nonetheless real, and financial theory would clearly suggest they should affect the market value of the firm and of the equity. The swap reduces cash flow risk but increases market value risk.

USING SWAPS TO CHANGE DURATION

LOS 38.d: Determine the notional principal value needed on an interest rate swap to achieve a desired level of duration in a fixed-income portfolio.

CFA® Program Curriculum, Volume 5, page 453

The duration of the portfolio plus a swap position (i.e., the target duration) is calculated as:

$$V_p(MD_T) = V_p(MD_p) + NP(MD_{\text{swap}})$$

where:

V_p = original value of the portfolio

MD_i = modified duration i (i = swap, target, portfolio without swap)

NP = notional principal of the swap

Usually, the portfolio manager selects a swap of a certain maturity which determines the modified duration of the swap, MD_{swap} . He then selects the NP that will achieve the desired MD_T . Rearranging, we can solve for the amount of notional principal necessary to achieve the target duration:

$$NP = \left(V_p \right) \left(\frac{MD_T - MD_p}{MD_{\text{swap}}} \right)$$



Professor's Note: This is just a variation of the basic bond hedging formula but set up to calculate notional principal rather than the number of contracts.

Example: Determining the notional principal

A manager of a \$60 million fixed-income portfolio with a duration of 5.2 wants to lower the duration to 4.0. The manager chooses a swap with a net duration of 3.1. What NP should the manager choose for the swap to achieve the target duration?

Answer:

From the given information, we have:

$$V_P = \$60,000,000$$

$$MD_P = 5.2$$

$$MD_{\text{swap}} = 3.1$$

$$MD_T = 4.0$$

$$NP = \left(V_P \right) \left(\frac{MD_T - MD_P}{MD_{\text{swap}}} \right)$$

$$NP = \$60,000,000 \left(\frac{4.0 - 5.2}{-3.1} \right) = \$23,225,806$$

Because the manager wants to *reduce* the duration of his portfolio, he should take a receive-floating/pay-fixed position in the swap with that notional principal. Remember that a receive-floating swap has a negative duration, so we enter -3.1 in the equation.

For the Exam: Be sure to enter the net duration of the swap correctly in the denominator of the equation (i.e., negative if pay-fixed; positive if receive-fixed). You can tell if you have entered it correctly because the sign on the notional principal should always be positive.

WARM-UP: CURRENCY SWAPS

A *currency swap* is different from an interest rate swap in two very important ways:

1. There are two notional principals, one in each currency, and the counterparties generally exchange the principals on the effective date and return them at the maturity date.
2. Because the cash flows in a currency swap are denominated in different currencies, the periodic interest payments are not usually settled on a net basis, so each counterparty makes a payment to the other in the appropriate currency.

A *plain vanilla currency swap* is one in which the floating-rate cash flows (usually based on LIBOR) are in dollars, while the other cash flows (in another currency, like euros) are based on a fixed rate. However, because swaps are OTC instruments, the counterparties can design them any way they choose (e.g., floating for floating, dollar floating and foreign fixed, fixed for fixed).

One of the more common reasons for a firm to engage in a currency swap is to gain access to loanable funds in a foreign currency that might be too costly to obtain from a bank, the reason being that the firm does not have close relationships with banks in the country of the desired currency.

A firm may also have issued a foreign-currency bond earlier, and now the firm wishes to *convert* it into a domestic obligation. A swap can help with that, too. If a U.S. company has a fixed-rate note denominated in euros and wishes to make it a synthetic dollar loan, the U.S. firm can enter into a receive-euro/pay-dollar swap. Because the plain vanilla currency swap exchanges fixed foreign currency for floating dollars, the U.S. firm's synthetic position will now be a floating-rate dollar obligation.

The following demonstration illustrates the mechanics of the swap in combination with the loans on both sides of the swap. Also, for added measure, we put the dealer in the mix, too! Dealers are involved in most transactions, and you may see them as part of an exam question.

Example: Currency swap

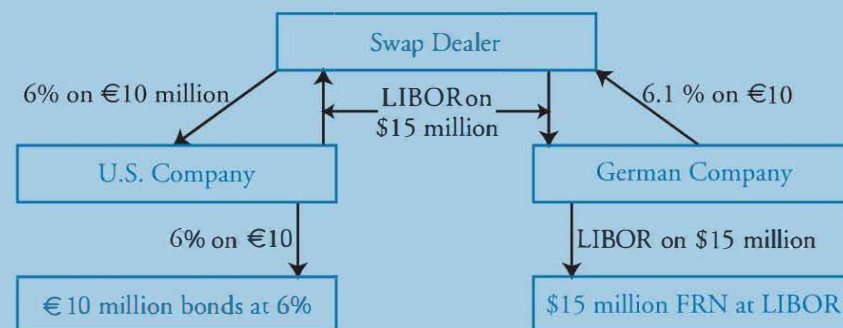
A U.S. company has a liability of €10 million in fixed-rate bonds outstanding at 6%. A German company has a \$15 million FRN outstanding at LIBOR. The exchange rate is \$1.5/€. The U.S. company enters into a plain vanilla currency swap with the swap dealer in which it pays LIBOR on \$15 million and receives the swap rate of 6.0% on €10 million. The German company also enters into a plain vanilla currency swap with the same dealer, in which it pays a swap rate of 6.1% on €10 million and receives LIBOR on \$15 million. One-year LIBOR is currently 5.2%.

Calculate each party's net borrowing cost, the principal cash flows at the initiation and maturity of the contract, and first-year cash flows (assume annual settlement).

Answer:

The cash flow for each settlement date for this plain vanilla currency swap is illustrated in the figure below.

Cash Flows for a Plain Vanilla Currency Swap



The U.S. company's net borrowing cost: LIBOR on \$15 million

$$(6\% \text{ on } €10 \text{ million}) + (\text{LIBOR on } \$15 \text{ million} - 6\% \text{ on } €10 \text{ million})$$

The German company's net borrowing cost: 6.1% on €10 million

$$(\text{LIBOR on } \$15 \text{ million}) + (6.1\% \text{ on } €10 \text{ million} - \text{LIBOR on } \$15 \text{ million})$$

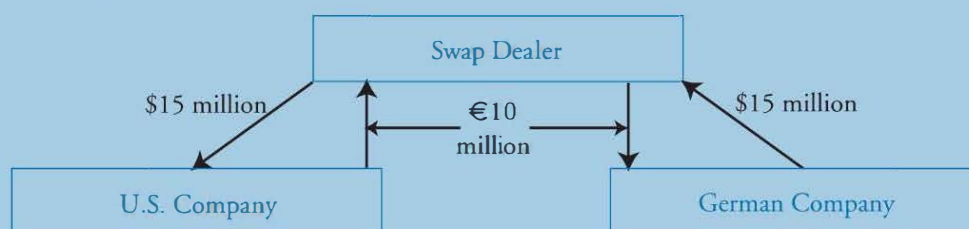
The swap dealer's spread: 0.1% on €10 million = €10,000

(LIBOR on \$15 million – 6% on €10 million) + (6.1% on €10 million – LIBOR on \$15 million)

Not only are the firms paying in different currencies, but they get access to the funds because they exchange notional principals at the beginning of the swap.

The cash flows of the notional principals at the initiation of the swap are shown in the figure below.

Exchange of Notional Principals



The U.S. Company

At the end of the first year, the U.S. company pays interest on its euro borrowing. It pays LIBOR and receives euros under the swap (the negative sign means outflow):

interest on euro borrowing	=	-€600,000	=	€10,000,000 × 0.060
euros received under swap	=	€600,000	=	€10,000,000 × 0.060
U.S. dollars paid under swap	=	-\$780,000	=	\$15,000,000 × 0.052
net cash flow	=	-\$780,000		

At the beginning of the period, the U.S. company gets a dollar principal and will pay dollars on the amount that was once a euro loan.

The German Company

The German company gets euros and will pay interest on its U.S. dollar borrowing. It receives LIBOR and pays euros under the swap:

interest on U.S. dollar borrowing	=	-\$780,000	=	\$15,000,000 × 0.052
euros paid under swap	=	-€610,000	=	€10,000,000 × 0.061
U.S. dollars received under swap	=	\$780,000	=	\$15,000,000 × 0.052
net cash flow	=	-€610,000		

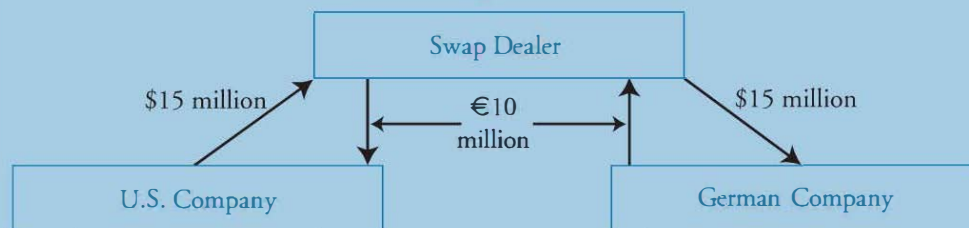
The Swap Dealer

The net cash flow to the swap dealer is:

euros received from German firm	=	€610,000	=	€10,000,000 × 0.061
euros paid to U.S. firm	=	€600,000	=	€10,000,000 × 0.060
net cash flow	=	€10,000	=	€10,000,000 × 0.001

The principal cash flows at maturity of the swap are shown below.

Cash Flows at the Maturity of the Swap



LOS 38.e: Explain how a company can generate savings by issuing a loan or bond in its own currency and using a currency swap to convert the obligation into another currency.

CFA® Program Curriculum, Volume 5, page 460

As mentioned earlier, a counterparty may use a currency swap to gain access to a foreign currency at a lower cost. Borrowing in a foreign country via a foreign bank may be difficult, and the interest rates may be high. A U.S. firm that wishes to initiate a project in a foreign country, say Korea, might not have the contacts necessary to borrow Korean currency (the won) cheaply. It may have to pay a high interest rate, such as 9%. A Korean counterparty may exist that would like to borrow dollars to invest in the United States but finds that banks in the United States charge 7.2% because they are unfamiliar with the Korean firm.

The U.S. firm can borrow at 6% in the United States because it has established relationships with those banks. It swaps the principal (borrowed dollars) with the Korean counterparty for the won, which the Korean firm borrowed at 7% in Korea. The U.S. firm uses its proceeds from its new business to pay the won interest to the Korean counterparty, who in turn pays won interest on its bank loan to the Korean bank. The Korean firm pays the dollar interest to the U.S. firm, who in turn pays dollar interest on its loan to the U.S. bank.

Here are the important points to this exchange:

- The U.S. firm is now paying 7% on a won loan on which it would have had to pay 9% if it had borrowed from a Korean bank.
- The Korean firm is now paying 6% on a dollar loan on which it would have had to pay 7.2% if it had borrowed from a U.S. bank.

A dealer might have increased the swap interest rates 10 basis points for each counterparty with the dealer earning the spread. But the resulting 7.1% for the U.S. firm is still less than 9%, and the resulting 6.1% is still less than 7.2% for the Korean firm.

Converting Foreign Cash Receipts

LOS 38.f: Demonstrate how a firm can use a currency swap to convert a series of foreign cash receipts into domestic cash receipts.

CFA® Program Curriculum, Volume 5, page 464

Dealers will contract with a firm in a currency swap that does not require an exchange of notional principals. This essentially becomes a series of exchange-rate purchases in the future at a fixed exchange rate. The amounts exchanged are a function of both the current exchange rate and interest rates (swap rates) in the countries involved.

As an example, let's consider a U.S. firm that wishes to convert its quarterly cash flows of €6 million each to dollars upon receipt. The exchange rate is currently €0.8/\$, and the swap rates in the United States and Europe are 4.8% and 5%, respectively. To obtain the swapped dollar cash flow, we first back out the notional principal in euros, translate this to a dollar notional principal, and then calculate the interest in dollars:

$$NP \left(\frac{0.05}{4} \right) = 6,000,000$$

$$NP = \frac{6,000,000}{\frac{0.05}{4}} = 480,000,000$$

The corresponding dollar amount is €480,000,000 / (€0.8/\$) = \$600,000,000. The quarterly interest payments on this amount would be \$600,000,000(0.048 / 4) = \$7,200,000.

The swap would then allow the firm to exchange its €6,000,000 quarterly inflow for \$7,200,000 per period. The maturity of the swap would be negotiated to meet the needs of the firm. You should note that no exchange of principals was required.

For the Exam: Follow these steps in determining the appropriate swap:

1. Divide the foreign cash flow received by the foreign interest rate to determine the corresponding foreign-denominated notional principal (NP).
 - a. This is the foreign NP that would have produced the foreign cash flow at the given foreign interest rate.
2. Using the current exchange rate, convert the foreign NP into the corresponding domestic NP.
3. Enter a swap with this NP.
 - a. Pay the foreign cash flows received on the assets and receive the equivalent domestic amount.
 - b. The amount of each domestic cash flow is determined by multiplying the domestic interest rate by the domestic NP.

Example: Currency swap without a notional principal exchange

A firm will be receiving a semiannual cash flow of €10 million. The swap rates in the United States and Europe are 6% and 5%, respectively. The current exchange rate is €0.9/\$. Identify the appropriate swap needed to convert the periodic euro cash flows to dollars.

Answer:

For the euros, the NP = €10,000,000 / (0.05 / 2) = €400,000,000. The corresponding dollar amount is €400,000,000 / 0.9 = \$444,444,444. Using these values for the swap, the firm will give the swap dealer €10,000,000 every six months over the maturity of the swap for:

$$\$444,444,444(0.06 / 2) = \$13,333,333$$

EQUITY SWAPS

LOS 38.g: Explain how equity swaps can be used to diversify a concentrated equity portfolio, provide international diversification to a domestic portfolio, and alter portfolio allocations to stocks and bonds.

CFA® Program Curriculum, Volume 5, page 469

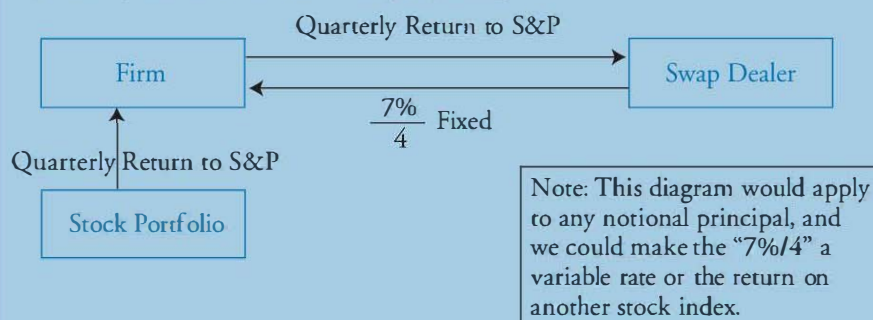
An equity swap is a contract where at least one counterparty makes payments based upon an equity position. The other counterparty may make payments based upon another equity position, a bond, or just fixed payments. We will begin with that example.

Example: Equity swap with fixed payments

A firm owns a stock portfolio that is closely correlated with the S&P 500. The firm is concerned that the stock market will fall over the next year. A 1-year, quarterly equity swap is available with a notional principal equal to the value of the portfolio and a fixed rate of 7%. **Diagram** the net quarterly cash flows to a hedge.

Answer:

The net effect for the firm is a fixed-rate return of $7\% / 4 = 1.75\%$ per period as shown below.

Quarterly Cash Flows to an Equity Swap

The swap does create some secondary risks, including:

- Counterparty risk if the swap dealer experiences difficulty and is unable to make the swap payments as expected to the firm.
- Basis risk if the return on the stock portfolio does not exactly match the S&P return payments the firm must make on the swap.
- Some cash flow risk in that the S&P payments to the swap dealer are unlikely to match the fixed payments to the firm. If a net is paid, the firm must have the cash available. Note: if the firm had sold the stock and actually bought fixed rate bonds, there is no cash flow risk as the firm just collects coupons.

Swaps to Create International Diversification

As a variation on the previous example, suppose the firm had a \$500 million equity portfolio and swapped \$100 million to receive the 7% fixed rate. The firm effectively has 20% fixed rate bond exposure. Now the firm does a second swap for \$50 million, paying the S&P return and receiving the return for the MSCI, an international stock index. This would further diversify the portfolio by creating a 10% allocation to international equity.

This second swap will have the same secondary risks as the first swap, but the cash flow risk is potentially even greater because the firm is receiving an index return rather than a known fixed rate. Consider the worst case scenario, where the S&P return paid is very large due to a high return on the S&P but the MSCI return is a large negative. The firm contracted to receive the MSCI return and when that return is negative, that means the firm must pay the MSCI return. The firm could end up making two payments with no receipt in a worst case scenario. Notice paying the MSCI return out when it is negative simply replicates the loss in value that would have occurred if the firm owned the MSCI and it declined. However, the swap requires cash to be paid, while owning the MSCI would only be a decline in market value. Economically they are the same result but the swap creates cash flow issues.

Benefits of using the swap are that transaction costs for the swap are generally lower than actually selling domestic stocks to buy international stocks. The swap can be for a defined period if this is a temporary exposure that is desired. Also the swap can be structured as payment in U.S. dollars to limit the foreign currency exposure from owning foreign denominated assets and any need to hedge the currency exposure. The dealer may consider these factors in pricing the swap, so the firm should consider whether the pricing is still attractive (to the firm).

Example: Diversifying concentrated positions

An investor has an overweighed 30,000 share position in a stock with a current market value of \$80 per share and a dividend yield of 2%. The investor wishes to reduce the position by half for a position in the S&P 500. **Demonstrate** how this can be accomplished with a swap.

Answer:

The owner of the stock would probably approach a dealer and swap the returns on \$1.2 million = $(30,000 \times \$80) / 2$ worth of the stock for the returns on a \$1.2 million investment in the S&P 500. Each settlement period (e.g., quarter) the total return on each position is calculated. The net amount is transferred between the parties.

Changing Allocations of Stock and Bonds

Another type of swapping of index returns can occur between, for example, large- and small-cap stocks. A firm with an equity portfolio that is 60% in large-cap stocks, 30% in mid-cap stocks, and 10% small-cap stocks can use a swap to synthetically adjust this position. If the value of the portfolio is \$200 million and the firm decides to make the large- and mid-cap exposure equal without touching the small-cap position, then it can become a counterparty in a swap that receives the return of the S&P Mid-Cap 400 Index and pays the return on the Dow Jones Industrial Average Index on a notional principal of 15% of \$200 million (i.e., \$30 million). Ignoring tracking error, this will synthetically make the portfolio a 45% large-cap, 45% mid-cap, and 10% small-cap stock portfolio over the life of the swap. The small-cap position is unaffected.

This concept can also be applied to the synthetic adjustment of a *bond portfolio*. A firm with a given portfolio of high-grade and low-grade bonds can enter into a swap that pays the return on an index of one type (e.g., the high-grade) and receives the return on the index of another type (e.g., the low-grade). *Do not confuse this with an interest rate swap!* In the swap based on bond returns, there is an interest component and a capital gain component just as there is in an equity swap.

Example: Changing allocations of stocks and bonds

We will consider a manager of a \$120 million bond portfolio that consists of \$80 million in investment-grade corporate bonds and \$40 million in U.S. Treasuries. The manager wants to switch the weights. **Demonstrate** how this can be accomplished with a swap.

Answer:

Once again, the manager approaches a dealer about swapping the returns on indices like the Barclays Capital Long-Term Treasury Bond Index and the Merrill Lynch Corporate Bond Index. The notional principal will be \$40 million.

INTEREST RATE SWAPTIONS

LOS 38.h: Demonstrate the use of an interest rate swaption 1) to change the payment pattern of an anticipated future loan and 2) to terminate a swap.

CFA® Program Curriculum, Volume 5, page 478

For the Exam: Be able to explain why and how a manager would use a swaption as well as calculate the payoff or cash flows to the swaption if exercised.

An *interest rate swaption* is an option on a swap where one counterparty (buyer) has paid a premium to the other counterparty (seller) for an option to choose whether the swap will actually go into effect on some future date. The terms of the swap are usually determined at the time of the swaption's inception, prior to the effective date of the swap. Swaptions can be either American or European in the same way as options. European-style swaptions may only be exercised on the expiration date, whereas an American-style swaption may be exercised on any day up to and including the expiration date.

There are two types of swaptions:

1. *Payer swaption:* A payer swaption gives the buyer the right to be the fixed-rate payer (and floating-rate receiver) in a prespecified swap at a prespecified date. The payer swaption is almost like a protective put in that it allows the holder to pay a set fixed rate, even if rates have increased.
2. *Receiver swaption:* A receiver swaption gives the buyer the right to be the fixed-rate receiver (and floating-rate payer) at some future date. The receiver swaption is the reverse of the payer swaption. In this case, the holder must expect rates to fall, and the swap ensures receipt of a higher fixed rate while paying a lower floating rate.

The key point is that the terms of the underlying swap and the swap fixed rate (SFR) are negotiated and set at the purchase of the swaption. The purchaser of the swaption can wait and see if subsequent market moves make that SFR attractive or not and then decide whether to turn on the underlying swap.

Payer Swaption

- If market interest rates move high enough at the expiration of the swaption such that the new SFR is above the swaption SFR, the holder of the payer swaption will exercise the option. Paying the swaption SFR is better than the terms on a new swap. The swaption swap has positive value.
- If interest rates move low enough such that the new SFR is below the swaption SFR, the holder would let the swaption expire worthless and only lose the premium paid. The swaption swap has negative value.

Receiver Swaption

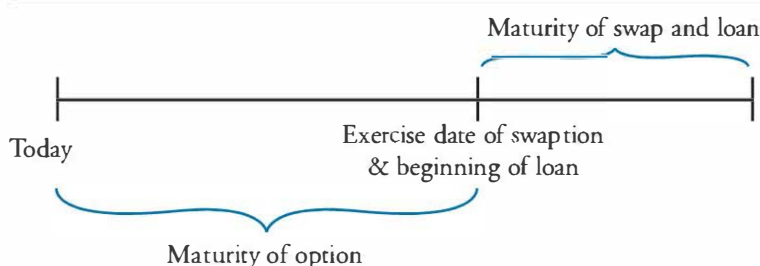
- If interest rates move high enough and the new SFR is above the swaption SFR, the holder of the swaption would let it expire worthless and only lose the premium paid. The SFR that would be received on the swaption SFR is unattractive and the swaption swap has negative value. A better SFR is available on a new swap.
- If market interest rates move low enough and the new SFR is below the swaption SFR, the swaption will be exercised. The swaption swap has positive value with an above market SFR to be received.

Using Swaptions to Hedge a Future Loan Transaction

A corporate manager may wish to purchase a fixed-rate payer swaption to synthetically *lock in* a maximum fixed rate to be paid on an FRN to be issued in the future. If interest rates decline, the manager can always let the option expire worthless and take advantage of lower rates. The time line is illustrated in Figure 1. Today the manager enters into a swaption by paying a premium. The option expires at the time the loan will be taken out. For generality, Figure 1 does not specify a floating- or fixed-rate loan.

- The payer swaption would convert a future floating-rate loan to a fixed-rate loan.
- The receiver swaption would convert a future fixed-rate loan to a floating-rate loan.

Figure 1: Swaption and Future Loan



As an example, if a manager is planning to take out a 3-year loan of \$10 million at a floating rate, say LIBOR plus 250 basis points, then the manager could hedge the risk of rising interest rates by purchasing a payer swaption with a notional principal of \$10 million. (The premium might be \$200,000, but the amount is not important for our discussion here. You should just know that an up-front premium is usually required.) The swap would be to receive 90-day LIBOR each quarter, to hedge the loan payments, and pay a fixed rate. The fixed rate might be 3.6% or 0.9% each quarter. At the exercise date of the swaption and the beginning of the loan, one of the following two scenarios will result.

1. The fixed rate on 3-year swaps that pay LIBOR is *greater than* 3.6%. Then the manager will exercise the swaption to pay the contracted 3.6% and receive LIBOR. We will recall our formula for a floating-rate borrower who is a floating-rate receiver in a swap:

$$\text{net payment} = \text{NP}[\text{swap rate} + (\text{loan spread})](D_c / 360)$$

In this case, the floating-rate loan plus swap will become a synthetic fixed-rate loan with the following quarterly payments (assuming 90-day settlement periods):

$$\text{net payment} = \$10,000,000(0.036 + 0.025)(90 / 360) = \$152,500$$

2. The fixed rate on 3-year swaps that pay LIBOR is *less than* 3.6%, say 3.2%. Then the manager will let the swaption expire, which means there was no realized benefit for the \$200,000 premium paid. The manager *may* contract, at a zero cost, to enter into a 3-year swap with a fixed rate of 3.2%. In this case, the floating-rate loan plus swap will become a synthetic fixed-rate loan with quarterly payments (assuming 90-day settlement periods):

$$\$142,500 = \$10,000,000 \times (0.032 + 0.025) \times (90 / 360)$$

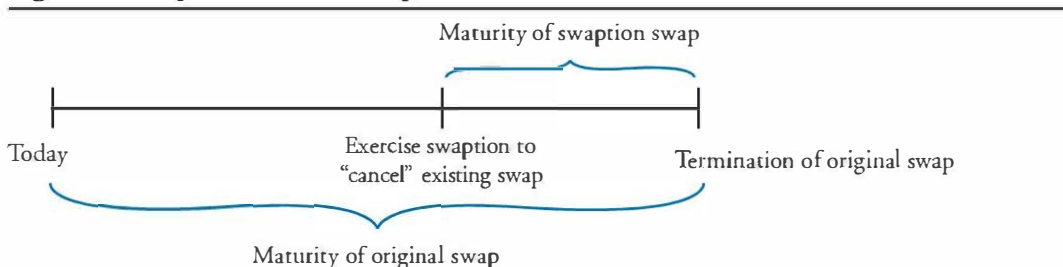
Scenario 2, the no-swaption exercise, could have had the manager not engage in any swap, even at the lower strike rate of 3.2%. That would be up to the manager. The concept is fairly simple. If exercised, the swap does its job. If not exercised, the manager is free to hedge or not hedge.

Using Swaptions to Potentially Terminate an Existing Swap Early

The actions outlined previously can easily be modified to apply to other situations. A manager who is under contract in an existing swap can enter into a swaption with the exact characteristics of the existing swap but take the other counterparty's position. It is possible to match the payments and characteristics because the premium can be adjusted to make the contract worthwhile to the dealer.

Figure 2 has the same general form as Figure 1, but it has been relabeled to depict a *cancellation* of an existing swap with a swaption.

Figure 2: Swaption Cancels Swap



A manager in a pay-floating swap with a given NP and swap fixed rate (SFR) would simply contract to be the receive-floating counterparty in a swaption that has an exercise date in the future. If the NP and SFR are the same for both the swaption and the swap, then upon exercise the swaption's cash flows will effectively *cancel* the cash flows of the existing swap. If the manager buys the swaption from the same dealer with whom the original swap was contracted, the position would effectively be closed. The purchaser of the swaption can then wait until expiration of the swaption and decide if market conditions make it attractive to turn on the swaption swap and effectively cancel the existing swap.

Synthetically Adding or Removing a Call Feature on Existing Debt



Professor's Note: There is no direct Learning Outcome Statement for the section on bond calls but it is in the assigned text. It would be an unlikely question.

Suppose a company has a non-callable 10-year bond issue outstanding and wishes it were callable in 3 years. The company could buy a 3-year swaption on a 7-year swap to pay floating and receive fixed. Now assume three years have passed:

- If interest rates are low enough, the company can exercise the swaption and enter the 7-year swap (the remaining term of the bond issue) to receive fixed and pay floating. The fixed receipts on the swap cover the fixed coupon payments on the bond and effectively convert it to floating (at now-low rates). This replicates the economic benefit the company would have received if the bond could have been called. If desired the company could even enter a new additional swap to receive floating (covering the floating payments the company must make on the executed swaption swap) and pay fixed. Interest rates are down and this new swap SFR will be low. It is as if the company called its debt and refinanced at new lower interest rates.
- If interest rates are high enough that the company would not have wanted to call the bond, the company does nothing and lets the swaption expire worthless.

Now suppose another company has a 5-year bond issue outstanding that is callable in 1 year. Further suppose the company does not expect rates to be low enough to make calling the bond worthwhile, or alternatively, the company needs cash today. The company could sell a 1-year swaption on a 4-year swap to pay fixed. Now assume one year has passed:

- If rates are high enough to make the swaption worthless, the purchaser of the swaption (who would receive fixed) will let it expire worthless. If the company still wants a fixed rate, the new SFR is a better deal. So nothing happens to the company who sold the swaption. The company continues to pay a fixed rate on its bond issue as the company would if it were not callable.
- Alternatively if rates fall low enough, the purchaser of the swaption will exercise and receive the swaption's SFR. In addition, the company will call the bonds in the low rate environment. The net is the company benefits from calling the bond but loses when the swaption is exercised and requires the company to pay fixed. The company gains and loses the benefit of calling the bond and economically is in a position as if the bond had not been callable.

KEY CONCEPTS

LOS 38.a

Interest rate swaps are used to change the nature of the cash flows (either fixed or floating) on assets and liabilities. A floating-rate (fixed-rate) payment on a liability can be effectively converted to a fixed-rate (floating-rate) by entering a pay-fixed, receive-floating (pay-floating, receive-fixed) swap. The goal is for the cash flow received on the swap to offset the original payment on the liability, such that the nature of the net payment on the liability is opposite from the original. For a floating- (fixed-) rate asset, the manager will enter a pay-floating, receive-fixed (pay-fixed, receive-floating) swap. The goal is to have the payment on the swap offset the receipt on the asset, such that the net receipt is opposite in nature from the original.

LOS 38.b

$$D_{\text{swap}} = D_{\text{asset}} - D_{\text{liability}}$$

For a pay-floating counterparty in a swap, the duration can be expressed as follows:

$$D_{\text{pay floating}} = D_{\text{fixed}} - D_{\text{floating}} > 0$$

For a pay-fixed counterparty, the duration can be expressed as follows:

$$D_{\text{pay fixed}} = D_{\text{floating}} - D_{\text{fixed}} < 0$$

LOS 38.c

Cash flow risk, uncertainty regarding the *size* of cash flows, is a concern with floating-rate instruments. Because their cash flows are reset each period according to the prevailing rate at the beginning of the period, however, their market values are subject to only minor changes.

Market value risk is a concern with fixed-rate instruments. A decline in interest rates, for example, increases the value of the liability (or pay-fixed side of a swap), thus increasing the liability of the borrower.

For individual assets and liabilities, the tradeoff is between the market value risk associated with fixed rates and the cash flow risk associated with floating rates.

LOS 38.d

The duration of the portfolio plus a swap position (i.e., the target duration) is calculated as:

$$V_p(MD_T) = V_p(MD_p) + NP(MD_{\text{swap}})$$

where:

V_p = original value of the portfolio

MD_i = modified duration i (i = swap, target, portfolio without swap)

NP = notional principal of the swap

Usually, the manager selects a swap of a certain maturity which determines the modified duration of the swap, MD_{swap} . He then selects the NP that will achieve the desired MD_T . Rearranging, we can solve for the amount of NP necessary to achieve the target duration as:

$$NP = (V_P) \left(\frac{MD_T - MD_P}{MD_{\text{swap}}} \right)$$

LOS 38.e

Borrowing in a foreign country via a foreign bank may be difficult, and the interest rates may be high. A U.S. firm that wishes to initiate a project in a foreign country, say Korea, might not have the contacts necessary to borrow Korean currency (the won) cheaply. A Korean counterparty may exist that would like to borrow dollars to invest in the United States.

The U.S. firm borrows in the United States because it has established relationships with banks in the United States. It swaps the principal (borrowed dollars) with the Korean counterparty for the won, which the Korean firm borrowed in Korea.

LOS 38.f

Follow these steps in determining the appropriate swap:

1. Divide the foreign cash flow received by the foreign interest rate to determine the corresponding foreign-denominated notional principal (NP).
 - a. This is the foreign NP that would have produced the foreign cash flow at the given foreign interest rate.
2. Using the current exchange rate, convert the foreign NP into the corresponding domestic NP.
3. Enter a swap with this NP.
 - a. Pay the foreign cash flows received on the assets and receive the equivalent domestic amount.
 - b. The amount of each domestic cash flow is determined by multiplying the domestic interest rate by the domestic NP.

LOS 38.g

A manager can swap all or part of the return on a portfolio for the return on a domestic equity index, the return on a foreign index, or the return on a fixed-income index. A manager desiring an exposure to foreign equities equivalent to 15% of the existing portfolio, for example, could enter a swap with a foreign NP equivalent to that amount. The manager pays the swap dealer the return on that portion of the portfolio and receives the return on the foreign equity index equivalent to an investment in the amount of the notional principal.

LOS 38.h

An *interest rate swaption* is an option on a swap where one counterparty (buyer) has paid a premium to the other counterparty (seller) for an option to choose whether the swap will actually go into effect on some future date. Swaptions can be either American or European in the same way as options.

1. *Payer swaption*: A payer swaption gives the buyer the right to be the fixed-rate payer (and floating-rate receiver) in a prespecified swap at a prespecified date. The payer swaption is almost like a protective put in that it allows the holder to pay a set fixed rate, even if rates have increased.
2. *Receiver swaption*: A receiver swaption gives the buyer the right to be the fixed-rate receiver (and floating-rate payer) at some future date. The receiver swaption is the reverse of the payer swaption. In this case, the holder must expect rates to fall, and the swap ensures receipt of a higher fixed rate while paying a lower floating rate.

The key point is that the terms of the underlying swap and the swap fixed rate (SFR) are negotiated and set at the purchase of the swaption. The purchaser of the swaption can wait and see if subsequent market moves make that SFR attractive or not and then decide whether to turn on the underlying swap.

CONCEPT CHECKERS

1. Which of the following would effectively transform a floating-rate liability to a fixed-rate liability? Enter into a contract as the:
 - A. fixed counterparty in an interest rate swap.
 - B. domestic counterparty in a currency swap.
 - C. floating counterparty in an interest rate swap.
2. Which of the following statements *most accurately* describes the rights of the counterparties in a swaption structure?
 - A. The holder of a receiver swaption has the right to enter a swap agreement as the fixed-rate receiver.
 - B. The holder of a payer swaption has the right to enter a swap agreement as the fixed-rate receiver.
 - C. The seller of a payer swaption has the right to enter a swap agreement as the fixed-rate payer.
3. A firm has most of its liabilities in the form of floating-rate notes with a maturity of two years and quarterly reset. The firm is not concerned with interest rate movements over the next four quarters but is concerned with potential movements after that. Which of the following strategies will allow the firm to hedge the expected change in interest rates?
 - A. Enter into a 2-year, quarterly pay-fixed, receive-floating swap.
 - B. Buy a swaption that allows the firm to be the fixed-rate payer upon exercise. In other words, go long a payer swaption with a 1-year maturity.
 - C. Buy a swaption that allows the firm to be the floating-rate payer upon exercise. In other words, go short a payer swaption with a 1-year maturity.
4. A firm issues fixed-rate bonds and simultaneously becomes a fixed-rate receiver counterparty in a corresponding plain vanilla interest rate swap. Which of the following *best* describes the subsequent, effective periodic interest payments of the firm? (SFR = swap fixed rate)
 - A. $SFR - [LIBOR - (\text{fixed rate on debt})]$.
 - B. $LIBOR - [(\text{fixed rate on debt}) - SFR]$.
 - C. $LIBOR - [SFR - (\text{fixed rate on debt})]$.
5. For a plain vanilla interest rate swap, a decrease in interest rates will *most likely*:
 - A. increase the value of the pay-fixed side of the swap.
 - B. decrease the value of the pay-fixed side of the swap.
 - C. leave the value of the pay-floating side unchanged.
6. A common reason for two potential borrowers in different countries to enter into a currency swap is to:
 - A. borrow cheap domestic and swap for foreign to reduce borrowing costs.
 - B. borrow cheap foreign and swap for domestic to reduce borrowing costs.
 - C. speculate on interest rate moves.

7. A firm has an \$8 million portfolio of large-cap stocks. The firm enters into an equity swap to pay a return based on the DJIA and receive a return based on the Russell 2000. To achieve an effective 60/40 mix of large-cap to small-cap exposure, the notional principal of the swap should be:
 - A. \$6.0 million.
 - B. \$4.8 million.
 - C. \$3.2 million.
8. For a pay-floating counterparty, the duration of the swap will generally be:
 - A. less than the duration of the fixed-rate payments.
 - B. equal to the duration of the fixed-rate payments.
 - C. greater than the duration of the fixed-rate payments.
9. A firm will be receiving a semiannual cash flow of €20 million. The swap rates in the United States and Europe are 4.0% and 4.6%, respectively. The current exchange rate is €1.2/\$. **Identify** the appropriate swap needed to convert the periodic euro cash flows to dollars.
10. A manager of a \$40 million dollar fixed-income portfolio with a duration of 4.6 wants to lower the duration to 3. The manager chooses a swap with a net duration of 2. **Determine** the notional principal that the manager should choose for the swap to achieve the target duration.
11. You are the treasurer of a company with a 4-year, \$20 million FRN outstanding at LIBOR. You are concerned about rising interest rates in the short term and would like to refinance at a fixed rate for the next two years. A swap dealer arranges a 2-year plain vanilla interest rate swap with annual payments in which you pay a fixed rate of 8.1% and receive LIBOR. The counterparty receives 7.9% and pays LIBOR. Assume that the counterparty has a \$20 million fixed-rate debt outstanding at 8%. One-year LIBOR is currently 7%. **Diagram and compute** each party's net borrowing cost and first-year cash flows.

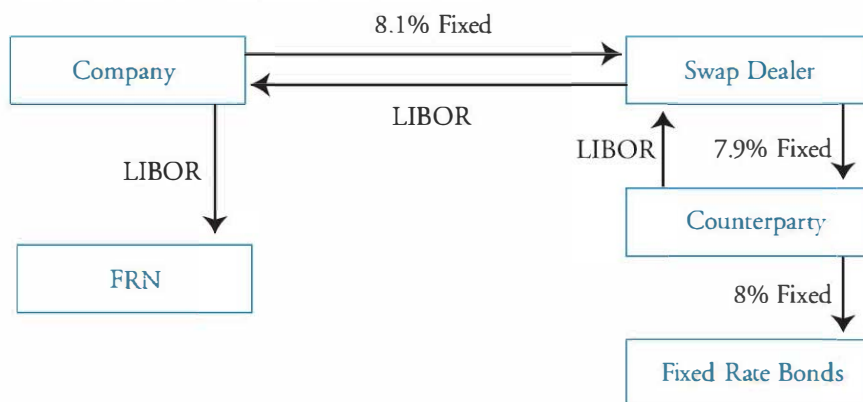
ANSWERS – CONCEPT CHECKERS

1. A As a pay-fixed counterparty, the borrower will receive a floating rate, which can pay the interest on the FRN. Thus, the borrower will pay a fixed rate on the entire position.
2. A The holder of a receiver swaption has the right to enter a swap agreement as the fixed-rate receiver.
3. B The firm is paying floating now but may want to lock in a fixed rate of interest if interest rates rise one year from now. Hence, buy a swaption that allows the firm to be the fixed-rate payer upon exercise. In other words, go long a payer swaption with a 1-year maturity.
4. C Given the selections, we assume that the reference rate is LIBOR, which is generally the case in a swap of this type. The firm will pay +LIBOR and receive (–) SFR and pay (–) the fixed rate on the debt. Essentially, the term $[SFR - (\text{fixed rate on debt})]$ is the net fixed rate paid, and it could be a positive or negative amount.
5. B Choice C is not correct because changes in rates affect both sides of the swap, and choice B best describes the result from a decrease in rates. The pay-fixed side of the swap will be paying an amount greater than the SFRs of newly issued swaps.
6. A A domestic borrower may be able to borrow at, say, 6% and swap the principal for a foreign currency. The domestic borrower will pay the counterparty the interest on the foreign currency received. This will presumably be lower than the rate the domestic borrower would have to pay if he had borrowed directly from a foreign bank. The foreign counterparty pays the interest on the domestic loan, which is presumably lower than that it would pay if it borrowed directly from a domestic bank.
7. C The notional principal should be 40% of the portfolio's value.
8. A Although most of the duration is associated with the fixed payments, the next *floating* payment is predetermined. Therefore, the duration of a quarterly-reset swap might be the duration of the fixed payments minus 0.125 ($0.25 / 2 = 0.125$).
9. For the euros, the $NP = 20,000,000 / (0.046 / 2) = €869,565,217$. The corresponding dollar amount is $\$724,637,681 = €869,565,217 / 1.2$. Using these values for the swap, the firm will give the swap dealer €20,000,000 every six months over the maturity of the swap for $\$724,637,681(0.04 / 2) = \$14,492,754$.
10. From the given information, we have:

$$\begin{aligned} V &= \$40,000,000 \\ MD_V &= 4.6 \\ MD_{\text{swap}} &= 2.0 \\ MD_T &= 3.0 \\ NP &= \$40,000,000 \times [(3.0 - 4.6) / -2] = \$32,000,000 \end{aligned}$$

The manager should take a receive-floating/pay-fixed position in the swap with a \$32,000,000 notional principal.

11. The box and arrow diagram is shown below:



Your net borrowing cost is:

$$(\text{LIBOR} - \text{LIBOR}) + 0.081 = 0.081 = 8.1\%$$

The counterparty's net borrowing cost is:

$$(0.080 - 0.079) + \text{LIBOR} = \text{LIBOR} + 0.001 = \text{LIBOR} + 0.1\%$$

The swap dealer's spread is:

$$0.002 = 0.20\% = 20 \text{ basis points} = (0.081 - 0.079) + (\text{LIBOR} - \text{LIBOR})$$

At the end of the first year, assuming LIBOR is 7%, your fixed-rate payment under the swap is:

$$\text{fixed-rate payment} = (0.081 - 0.07)(\$20,000,000) = \$220,000$$

Your total interest costs equal the LIBOR-based interest payments plus the swap payment:

$$\$20,000,000(0.07) + \$220,000 = \$1,620,000$$

At the end of the first year, the counterparty's fixed-rate receipt under the swap is:

$$(\text{fixed-rate receipt}) = (0.079 - 0.07)(\$20,000,000) = \$180,000$$

The counterparty's total interest costs equal the 8% interest payment on their outstanding fixed-rate debt minus the swap payment:

$$\$20,000,000(0.08) - \$180,000 = \$1,420,000$$

The cash flows to the swap dealer are:

$$\$220,000 - \$180,000 = (\$20,000,000 \times 0.002) = \$40,000$$

Everybody is happy. You've converted floating-rate debt to fixed-rate debt, your counterparty has converted fixed-rate debt to floating-rate debt, and the swap dealer has made \$40,000 without being exposed to interest rate risk.

FORMULAS

annual hedge fund Sharpe ratios:

$$\text{Sharpe}_{\text{HF}} = \frac{\text{annualized return} - \text{annualized risk-free rate}}{\text{annualized standard deviation}}$$

$$\text{swap rate} = \frac{\sum_{t=1}^T (\text{FDF}_t) \times (\text{forward rate})_t}{\sum_{t=1}^T \text{FDF}_t}$$

$$\text{swap price} = \frac{\sum_{t=1}^T (\text{FDF}_t) \times (\text{forward price of commodity})_t}{\sum_{t=1}^T \text{FDF}_t}$$

financial settlements of interest rate swaps and commodity swaps:

$$\text{settlement} = (\text{difference between fixed and market values}) \times (\text{notional principal})$$

basic expression relating forward and spot prices:

$$F_{0,T} = S_0 e^{R_F T}$$

$$F_{0,T} = S_0 e^{(R_F - c)T} < S_0 e^{R_F T}$$

where c = the convenience yield, or

$$F_{0,T} = S_0 e^{(R_F - \delta)T} < S_0 e^{R_F T}$$

where δ = the lease rate, or

$$F_{0,T} = S_0 e^{(R_F + \lambda)T} > S_0 e^{R_F T}$$

where λ = the storage costs, or

$$F_{0,T} = S_0 e^{(R_F + \lambda - c)T}$$

range of no-arbitrage prices:

$$S_0 e^{(R_F + \lambda - c)T} \leq F_{0,T} \leq S_0 e^{(R_F + \lambda)T}$$

information ratio (IR):

$$IR_P = \frac{\text{active return}}{\text{active risk}} = \frac{R_P - R_B}{\sigma_{(R_P - R_B)}}$$

$$VAR = [\hat{R}_P - (z)(\sigma)] V_P$$

$$\sigma_{\text{daily}} \cong \frac{\sigma_{\text{annual}}}{\sqrt{250}}; \sigma_{\text{mont ly}} \cong \frac{\sigma_{\text{annual}}}{\sqrt{12}}; \sigma_{\text{daily}} \cong \frac{\sigma_{\text{mont ly}}}{\sqrt{22}}$$

$$\text{forward contract credit risk exposure: value}_{\text{manager}} = PV_{\text{inflows}} - PV_{\text{outflows}}$$

$$\text{Sharpe ratio: } S_P = \frac{\bar{R}_P - \bar{R}_F}{\sigma_P}$$

$$\text{Sortino ratio: } \text{Sortino} = \frac{\bar{R}_P - \text{MAR}}{\text{downside deviation}}$$

$$\text{return over maximum drawdown: } \text{RoMAD} = \frac{\bar{R}_P}{\text{maximum drawdown}}$$

optimal hedge ratio, h :

$$h = h_T + h_E \Rightarrow h_T = 1 \text{ and } h_E = \frac{\text{Cov}(R_L, R_C)}{\sigma_{R_C}^2}$$

delta, δ :

$$\delta = \frac{\Delta P}{\Delta E} = \frac{P_1 - P_0}{E_1 - E_0}$$

$$\beta_i = \frac{\text{Cov}(i, m)}{\sigma_m^2}$$

$$\text{number of contracts} = \left(\frac{\beta_T - \beta_P}{\beta_f} \right) \left(\frac{V_P}{P_f (\text{multiplier})} \right)$$

$$\text{number of contracts}_{\text{UNrounded}} = \frac{(T_{\text{hclld}})(1 + R_F)^t}{(P_f)(\text{multiplier})}$$

$$\# \text{ equity contracts} = -\frac{V_P (1 + R_F)^T}{P_f}$$

$$\# \text{ equity index contracts} = \left(\frac{\beta_T - \beta_P}{\beta_f} \right) \left(\frac{V_P}{P_f (\text{multiplier})} \right)$$

$$\text{number of contracts} = (\text{yield beta}) \left(\frac{MD_T - MD_P}{MD_F} \right) \left(\frac{V_P}{P_f (\text{multiplier})} \right)$$

$$\text{interest rate call payoff} = (NP)[\max(0, \text{LIBOR} - \text{strike rate})](D / 360)$$

$$\text{interest rate put payoff} = (NP)[\max(0, \text{strike rate} - \text{LIBOR})(D / 360)]$$

$$\Delta_{\text{call}} = \frac{C_1 - C_0}{S_1 - S_0} = \frac{\Delta C}{\Delta S}$$

$$\text{gamma} = (\text{change in delta}) / (\text{change in } S)$$

$$D_{\text{pay floating}} = D_{\text{fixed}} - D_{\text{floating}} > 0$$

$$D_{\text{pay-fixed}} = D_{\text{floating}} - D_{\text{fixed}} < 0$$

duration of the portfolio plus a swap position:

$$V_P (MD_T) = V_P (MD_P) + NP (MD_{\text{swap}})$$

$$\text{solving for swap NP: } NP = \left(V_P \right) \left(\frac{MD_T - MD_P}{MD_{\text{swap}}} \right)$$

APPENDIX: AREAS UNDER THE NORMAL CURVE

Some of the examples in this book have used one version of the z -table to find the area under the normal curve. This table provides the cumulative probabilities (or the area under the entire curve to the left of the z -value).

Probability Example

Assume that the annual earnings per share (EPS) for a large sample of firms is normally distributed with a mean of \$5.00 and a standard deviation of \$1.50. What is the approximate probability of an observed EPS value falling between \$3.00 and \$7.25?

If $\text{EPS} = x = \$7.25$, then $z = (x - \mu) / \sigma = (\$7.25 - \$5.00) / \$1.50 = +1.50$

If $\text{EPS} = x = \$3.00$, then $z = (x - \mu) / \sigma = (\$3.00 - \$5.00) / \$1.50 = -1.33$

Solving Using the Cumulative Z -Table

For z -value of 1.50: Use the row headed 1.5 and the column headed 0 to find the value 0.9332. This represents the area under the curve to the left of the critical value 1.50.

For z -value of -1.33: Use the row headed 1.3 and the column headed 3 to find the value 0.9082. This represents the area under the curve to the left of the critical value +1.33. The area to the left of -1.33 is $1 - 0.9082 = 0.0918$.

The area between these critical values is $0.9332 - 0.0918 = 0.8414$, or 84.14%.

Hypothesis Testing—One-Tailed Test Example

A sample of a stock's returns on 36 non-consecutive days results in a mean return of 2.0%. Assume the population standard deviation is 20.0%. Can we say with 95% confidence that the mean return is greater than 0%?

$H_0: \mu \leq 0.0\%$, $H_A: \mu > 0.0\%$. The test statistic = z -statistic = $\frac{\bar{x} - \mu_0}{\sigma / \sqrt{n}}$
 $= (2.0 - 0.0) / (20.0 / 6) = 0.60$.

The significance level = $1.0 - 0.95 = 0.05$, or 5%. Because we are interested in a return greater than 0.0%, this is a one-tailed test.

Using the Cumulative Z -Table

Because this is a one-tailed test with an alpha of 0.05, we need to find the value 0.95 in the cumulative z -table. The closest value is 0.9505, with a corresponding critical z -value of 1.65. Because the test statistic is less than the critical value, we fail to reject H_0 .

Hypothesis Testing—Two-Tailed Test Example

Using the same assumptions as before, suppose that the analyst now wants to determine if he can say with 99% confidence that the stock's return is not equal to 0.0%.

$H_0: \mu = 0.0\%$, $H_A: \mu \neq 0.0\%$. The test statistic (z -value) = $(2.0 - 0.0) / (20.0 / 6) = 0.60$. The significance level = $1.0 - 0.99 = 0.01$, or 1%. Because we are interested in whether or not the stock return is nonzero, this is a two-tailed test.

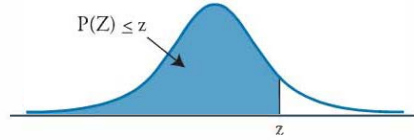
Using the Cumulative Z -Table

Because this is a two-tailed test with an alpha of 0.01, there is a 0.005 rejection region in both tails. Thus, we need to find the value 0.995 ($1.0 - 0.005$) in the table. The closest value is 0.9951, which corresponds to a critical z -value of 2.58. Because the test statistic is less than the critical value, we fail to reject H_0 and conclude that the stock's return equals 0.0%.

CUMULATIVE Z-TABLE

$P(Z \leq z) = N(z)$ for $z \geq 0$

$P(Z \leq -z) = 1 - N(z)$

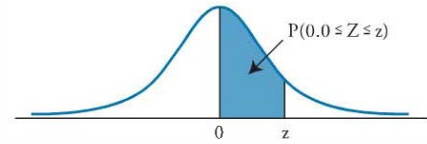


z	0	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0	0.5000	0.5040	0.5080	0.5120	0.5160	0.5199	0.5239	0.5279	0.5319	0.5359
0.1	0.5398	0.5438	0.5478	0.5517	0.5557	0.5596	0.5636	0.5675	0.5714	0.5753
0.2	0.5793	0.5832	0.5871	0.5910	0.5948	0.5987	0.6026	0.6064	0.6103	0.6141
0.3	0.6179	0.6217	0.6255	0.6293	0.6331	0.6368	0.6406	0.6443	0.6480	0.6517
0.4	0.6554	0.6591	0.6628	0.6664	0.6700	0.6736	0.6772	0.6808	0.6844	0.6879
0.5	0.6915	0.6950	0.6985	0.7019	0.7054	0.7088	0.7123	0.7157	0.7190	0.7224
0.6	0.7257	0.7291	0.7324	0.7357	0.7389	0.7422	0.7454	0.7486	0.7517	0.7549
0.7	0.7580	0.7611	0.7642	0.7673	0.7704	0.7734	0.7764	0.7794	0.7823	0.7852
0.8	0.7881	0.7910	0.7939	0.7967	0.7995	0.8023	0.8051	0.8078	0.8106	0.8133
0.9	0.8159	0.8186	0.8212	0.8238	0.8264	0.8289	0.8315	0.8340	0.8365	0.8389
1	0.8413	0.8438	0.8461	0.8485	0.8508	0.8531	0.8554	0.8577	0.8599	0.8621
1.1	0.8643	0.8665	0.8686	0.8708	0.8729	0.8749	0.8770	0.8790	0.8810	0.8830
1.2	0.8849	0.8869	0.8888	0.8907	0.8925	0.8944	0.8962	0.8980	0.8997	0.9015
1.3	0.9032	0.9049	0.9066	0.9082	0.9099	0.9115	0.9131	0.9147	0.9162	0.9177
1.4	0.9192	0.9207	0.9222	0.9236	0.9251	0.9265	0.9279	0.9292	0.9306	0.9319
1.5	0.9332	0.9345	0.9357	0.937	0.9382	0.9394	0.9406	0.9418	0.9429	0.9441
1.6	0.9452	0.9463	0.9474	0.9484	0.9495	0.9505	0.9515	0.9525	0.9535	0.9545
1.7	0.9554	0.9564	0.9573	0.9582	0.9591	0.9599	0.9608	0.9616	0.9625	0.9633
1.8	0.9641	0.9649	0.9656	0.9664	0.9671	0.9678	0.9686	0.9693	0.9699	0.9706
1.9	0.9713	0.9719	0.9726	0.9732	0.9738	0.9744	0.9750	0.9756	0.9761	0.9767
2	0.9772	0.9778	0.9783	0.9788	0.9793	0.9798	0.9803	0.9808	0.9812	0.9817
2.1	0.9821	0.9826	0.983	0.9834	0.9838	0.9842	0.9846	0.985	0.9854	0.9857
2.2	0.9861	0.9864	0.9868	0.9871	0.9875	0.9878	0.9881	0.9884	0.9887	0.989
2.3	0.9893	0.9896	0.9898	0.9901	0.9904	0.9906	0.9909	0.9911	0.9913	0.9916
2.4	0.9918	0.9920	0.9922	0.9925	0.9927	0.9929	0.9931	0.9932	0.9934	0.9936
2.5	0.9938	0.994	0.9941	0.9943	0.9945	0.9946	0.9948	0.9949	0.9951	0.9952
2.6	0.9953	0.9955	0.9956	0.9957	0.9959	0.9960	0.9961	0.9962	0.9963	0.9964
2.7	0.9965	0.9966	0.9967	0.9968	0.9969	0.9970	0.9971	0.9972	0.9973	0.9974
2.8	0.9974	0.9975	0.9976	0.9977	0.9977	0.9978	0.9979	0.9979	0.9980	0.9981
2.9	0.9981	0.9982	0.9982	0.9983	0.9984	0.9984	0.9985	0.9985	0.9986	0.9986
3	0.9987	0.9987	0.9987	0.9988	0.9988	0.9989	0.9989	0.9989	0.9990	0.9990

ALTERNATIVE Z-TABLE

$P(Z \leq z) = N(z)$ for $z \geq 0$

$P(Z \leq -z) = 1 - N(z)$



z	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.0	0.0000	0.0040	0.0080	0.0120	0.0160	0.0199	0.0239	0.0279	0.0319	0.0359
0.1	0.0398	0.0438	0.0478	0.0517	0.0557	0.0596	0.0636	0.0675	0.0714	0.0753
0.2	0.0793	0.0832	0.0871	0.0910	0.0948	0.0987	0.1026	0.1064	0.1103	0.1141
0.3	0.1179	0.1217	0.1255	0.1293	0.1331	0.1368	0.1406	0.1443	0.1480	0.1517
0.4	0.1554	0.1591	0.1628	0.1664	0.1700	0.1736	0.1772	0.1808	0.1844	0.1879
0.5	0.1915	0.1950	0.1985	0.2019	0.2054	0.2088	0.2123	0.2157	0.2190	0.2224
0.6	0.2257	0.2291	0.2324	0.2357	0.2389	0.2422	0.2454	0.2486	0.2517	0.2549
0.7	0.2580	0.2611	0.2642	0.2673	0.2704	0.2734	0.2764	0.2794	0.2823	0.2852
0.8	0.2881	0.2910	0.2939	0.2967	0.2995	0.3023	0.3051	0.3078	0.3106	0.3133
0.9	0.3159	0.3186	0.3212	0.3238	0.3264	0.3289	0.3315	0.3340	0.3356	0.3389
1.0	0.3413	0.3438	0.3461	0.3485	0.3508	0.3531	0.3554	0.3577	0.3599	0.3621
1.1	0.3643	0.3665	0.3686	0.3708	0.3729	0.3749	0.3770	0.3790	0.3810	0.3830
1.2	0.3849	0.3869	0.3888	0.3907	0.3925	0.3944	0.3962	0.3980	0.3997	0.4015
1.3	0.4032	0.4049	0.4066	0.4082	0.4099	0.4115	0.4131	0.4147	0.4162	0.4177
1.4	0.4192	0.4207	0.4222	0.4236	0.4251	0.4265	0.4279	0.4292	0.4306	0.4319
1.5	0.4332	0.4345	0.4357	0.4370	0.4382	0.4394	0.4406	0.4418	0.4429	0.4441
1.6	0.4452	0.4463	0.4474	0.4484	0.4495	0.4505	0.4515	0.4525	0.4535	0.4545
1.7	0.4554	0.4564	0.4573	0.4582	0.4591	0.4599	0.4608	0.4616	0.4625	0.4633
1.8	0.4641	0.4649	0.4656	0.4664	0.4671	0.4678	0.4686	0.4693	0.4699	0.4706
1.9	0.4713	0.4719	0.4726	0.4732	0.4738	0.4744	0.4750	0.4756	0.4761	0.4767
2.0	0.4772	0.4778	0.4783	0.4788	0.4793	0.4798	0.4803	0.4808	0.4812	0.4817
2.1	0.4821	0.4826	0.4830	0.4834	0.4838	0.4842	0.4846	0.4850	0.4854	0.4857
2.2	0.4861	0.4864	0.4868	0.4871	0.4875	0.4878	0.4881	0.4884	0.4887	0.4890
2.3	0.4893	0.4896	0.4898	0.4901	0.4904	0.4906	0.4909	0.4911	0.4913	0.4916
2.4	0.4918	0.4920	0.4922	0.4925	0.4927	0.4929	0.4931	0.4932	0.4934	0.4936
2.5	0.4939	0.4940	0.4941	0.4943	0.4945	0.4946	0.4948	0.4949	0.4951	0.4952
2.6	0.4953	0.4955	0.4956	0.4957	0.4959	0.4960	0.4961	0.4962	0.4963	0.4964
2.7	0.4965	0.4966	0.4967	0.4968	0.4969	0.4970	0.4971	0.4972	0.4973	0.4974
2.8	0.4974	0.4975	0.4976	0.4977	0.4977	0.4978	0.4979	0.4979	0.4980	0.4981
2.9	0.4981	0.4982	0.4982	0.4983	0.4984	0.4984	0.4985	0.4985	0.4986	0.4986
3.0	0.4987	0.4987	0.4987	0.4988	0.4988	0.4989	0.4989	0.4989	0.4990	0.4990

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